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LEFT-HANDEDNESS AND MIRROR WRITING, ESPECIALLY AMONG DEFECTIVE CHILDREN.

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CHAPTER I.—INTRODUCTION.

THE following observations and experiments were made, unless otherwise stated, in special schools (for mentally defective children) in London and Middlesex.

The Elementary Education (Defective and Epileptic Children) Act, 1899, defines the children, for whom these schools are provided, as "not being imbecile and not being merely dull or backward, are defective, that is to say, children, by reason of mental or physical defect, are incapable of receiving proper benefit from the instruction in the ordinary public elementary schools, but are not incapable, by reason

of such defect, of receiving benefit from instruction in special classes or schools, &c."

The investigation originated from an observation made in April, 1918, during the inspection of one of these special schools. In one of the classes nine (37 per cent.) of the children out of twenty-four were writing with their left hands, and doing most of their work left-handedly. At other mental defective schools the percentage of left-handed children appeared to be very high; and head teachers frequently reported that there was a large number of left-handed children in their schools. As the percentage of left-handed children was undoubtedly much higher in mental defective than in the ordinary elementary schools, an attempt was made to determine as accurately as possible their number, and to include in this number those who were originally left-handed, but who had been converted into right-handedness in many of their activities by the pressure brought to bear on them by parents or teachers.

A left-handed child was taken to be one who would use the left hand in preference to the right in such activities as are usually carried out by the right hand in the case of right-handed children. It was originally considered important that the tests should be in such things as might have passed unnoticed by parents and teachers, and for this reason might have remained unchanged. Owing to little time being available at first for the investigation, it was necessary that the tests should be of the simplest character and that they could be applied rapidly, and to whole classes. A great variety of experiments have been made, and only those tests which gave consistent results have been retained. The methods used and the results obtained will be given later.

The high percentage of left-handed children in mental defective schools does not appear to have received any special attention. The following references, however, are of interest in connection with the subject.

Ballard in an investigation on "Sinistrality and Speech" in 1912, notices a higher percentage of left-handed children in mental defective schools than in ordinary elementary schools, i.e., 6·5 per cent. against 4·1 per cent.[1] In both percentages he includes sinistrals (left-handed writers, &c.), and what he calls dextro-sinistrals (left-handed children who write with the right hand).

Smedley [28], 1899, in some experiments on the "strength of grip"

[1] These numbers were obtained from reports, &c., from the schools. In his own investigations he gives the percentage in ordinary schools as 2·8 per cent.

of right and left hand concludes that "dull pupils are more ambidextrous than average, and average than bright pupils; while the John Worthy school boys (incorrigibles, truants, &c., Chicago), are more ambidextrous than the dull pupils of the regular schools."

In other experiments on children, e.g., in the "tapping tests" (i.e., tapping as rapidly as possible with the right and with the left hand in a given time), Smedley again comes to the same conclusion: "left hand efficiency nearly approaches right hand efficiency in the case of dull and backward children." This conclusion, however, is not confirmed by Bolton. It must not, however, be forgotten that, in the case of left-handed children and adults who write with the right hand, the difference between the efficiency of the hands is likely to be less than when a person is simply right-handed or left-handed. In fact, during the present investigation there appeared to be little evidence of real ambidexterity; there were a few exceptional cases in which either hand was used indiscriminately. The children were of very low-grade type, and their lack of so-called "dexterity" was very marked in the case of both hands.

In "Ambidexterity," J. Jackson [13] refers to the opinion that the insane have a great percentage of "partial ambidexters" in their ranks, and that there is a high percentage of left-handed among criminals; also that left-handed children have been looked upon as somewhat daft, hence nurses and parents did their best to make them right-handed.

Lombroso, however, states that the percentage of left-handed among lunatics does not greatly differ from that among normal people, but that it is much higher among criminals (*North American Review*, 1903). Mayet (1902) found a high percentage (16 to 30) of ambidextrous and left-handed among idiots and epileptics. Lombroso himself considered left-handedness as a sign of degeneracy.

Ballard in 1912 [5] and W. Franklin Jones [14] in 1918 both came to the conclusion that stammering in a high percentage of cases is closely associated with the "transfer" of congenital left-handers to right-handedness in writing and vice versa.

General attitude of teachers towards left-handed children.—In mental defective schools, teachers as a rule after some attempts at converting left-handed children into right-hand writers, and if these attempts are not very successful, leave them to their own devices. Knitting and sewing however are treated differently in the majority of cases, owing to the difficulty experienced by teachers in teaching these subjects left-handedly. As a matter of fact very few were found

to knit or sew left-handedly. Probably the lack of adaptability of mentally defective children renders it extremely difficult to bring about these changes (especially in writing); and this may explain why teachers in these schools have found it advisable to leave the children alone. In one school the teachers try to make all the scholars right-hand writers. In this school twenty-eight (46 per cent.) out of a total of sixty-one were found to be left-handed by the various tests described later. Of these twenty-eight, sixteen were well known to have written or to have drawn with their left hand at one time or other. In connection with this point it must be remembered that few children are sent to these special schools before the age of eight, and it is therefore highly probable that most of them have experienced some pressure to make them write with their right hand. Clearly also the pressure had been insufficient to bring about the change. Of these twenty-eight, thirteen are reported to have some "speech difficulties," and two to be "defective in speech," one to "stutter," and two to "stammer" at times. Too much stress must not be laid on such defectiveness, as difficulties in speech apart from left-handedness are not uncommon among this class of children. At another school the children are especially trained in ambidexterity and even in writing with both hands.

In ordinary elementary schools, teachers generally assert that at the present time little or no pressure is brought to bear on left-handed children. As a matter of fact most left-handed children are subjected to some pressure either by teachers or parents, but generally unaccompanied by any harshness. A great many of these left-handed children are of a highly nervous temperament, and in many cases this nervousness does not appear to be due to a forced change of hands, or to an unsuccessful attempt to convert them into right-hand writers. It is however difficult to say anything very positively, as it is almost impossible to ascertain the true facts of each case.

Chapter II.—Tests and Methods of Examination.

§ 1.—*Tests.*

A great many experiments have been made, e.g., kicking, tying knots, the use of the hammer and saw, &c., but in most of these many difficulties were encountered, and in some it was found that the results were inconsistent with the known facts. In kicking a ball for example, it was often found that thoroughly left-handed boys kicked with the

right foot, and in the case of girls and younger children no reliance could be placed on the results, as they frequently kicked with the foot which happened to be in the most convenient position when they reached the ball.

Originally all children, who could write their names, were asked to make the attempt with their left hand, as it was expected that the result might indicate those who had some skill with this hand. The instructions were very simple ; the children were told to take their pencils in their left hand and to hold them up. In this way it could be seen that everyone had them in the left hand. They were then asked to write their names with that hand, on a slip of paper that had been given them. After a little hesitation nearly everyone made the attempt. It was interesting to note the difficulties they experienced, and how they overcame these difficulties. Many began by holding the pencil four or five inches from the pointed end and attempted to write with an arm, instead of a wrist or finger movement. As a rule however they gradually changed to a more suitable position and movement. It was remarkable—considering the class of children—how well they wrote their names as a rule. One peculiarity was immediatey noticed —namely "mirror writing." As this type of writing was found to be prevalent among mental defectives, a special investigation was made into the matter, the results of which are given separately.

After prolonged experiments the following tests were found to be the most reliable and most consistent with known facts. In fact very seldom was a known left-handed child missed, and very frequently left-handed children, unknown to the teacher, were discovered who on careful inquiry were found to have been left-handed in their earlier school career.

(*a*) *Rubbing and throwing test.*—The names of the children in a class were written on a sheet of foolscap and the experimenter went round to each child with a duster and placed it on the desk, asking the child to give the desk a good rub. As a rule the child seized the duster, and rubbed the desk vigorously with the right hand ; the left-handed child, however, seized the duster and rubbed the desk with the left hand. It was very necessary to look at the non-rubbing hand, as not infrequently a right-handed child with a penny or handkerchief in the right hand rubbed with the left hand. Those who rubbed with the left hand were immediately asked to stand at the back of the room, and to catch the folded-up duster and throw it back. In infant schools these two tests were remarkably successful. The test was very quickly

carried out; and throwing with the left was found very often to be associated with left-hand rubbing. The teacher, who had the list of names, entered "L" in the columns headed "Rub" and "Throw" in the case of those who did it with their left hand. When a child rubbed with the left hand and threw with the right, he was again asked to rub the desk, care being taken to place the duster so that it could be taken more easily with the right. If he still persisted in rubbing with the left the letter "L" was entered, but, if he now changed to the right, the letter was entered but a line was drawn through it. Interesting cases were continually met with when a child was asked to catch the duster; some immediately placed the left hand behind their backs or held their left arm stiffly down with their fist clenched and put the other hand well in front. Some of these actually rolled up the duster with the right hand, still holding the left arm down or behind them. It was evident they were not acting in a natural way, that they were in fact inhibiting the natural action.

Among the older children in ordinary schools, i.e., those above Standard II (about 8½ years of age) and in the elder boys and girls, special schools (over 12), the rubbing and throwing tests were not so successful for various reasons. Often those who were being tested soon understood the object of the test; some wished to conceal their left-handedness, others thought that the trial was to find out those who could throw well with the left hand. It is important in these and the following test that both should be made before any knowledge of their exact purpose has been gained.

As an example of the result of these two tests the following is given :—

Infant school, the lowest class, ages 4½ to 5½, forty-one boys and girls. Seven were found to rub and throw with the left hand and one to rub with the left but throw with the right. Three days afterwards the whole class were asked to draw anything they liked, and the seven drew with the left hand, and all the others with the right.

(*b*) *Throwing tests.*—A test for older boys and girls. A waste-paper basket was placed about four or five yards from a line marked on the floor. After explaining that it was wished to discover those who could throw the straightest, by seeing who could throw a knotted duster into the basket from the line marked on the floor, the experimenter sat at the table with the list and called out in order the names of the boys or girls, and noted those who threw with the left hand. In this way the test was carried out without the "subjects" having any knowledge of the real object of the experiment.

The results of this test in three elder boys' schools (for mentally defective) are given below :—

School A.—Classes 1 and 2: thirty-one boys, ages 13 years to 16 years 8 months. Five boys (and five boys only) threw with the left hand; all of these and no others were conclusively proved to be left-handed. Of these, two always write with the left hand, and one with the right; the remaining two write with the right, but used to write at one time with the left.

School B.—Classes 1 and 2: forty-six boys. Four boys threw with the left; of these three were proved to be left-handed, and they write with the left hand. One had some clear indications of left-handedness, but writes with the right hand. Of the rest, three who threw with the right, each had some slight indications of left-handedness, but insufficient to be noted as left-handed; they all write with the right hand.

School C.—Classes 1 and 2: sixty-one boys, ages 11 years 9 months to 15 years 10 months. Six boys threw with the left; of these five were proved to be left-handed; four of them write with the left and one now writes with the right, but used to write with the left at one time. Of the remainder, two boys who threw with the right, one was clearly left-handed; he draws and writes with the left hand: one had some indications of left-handedness, and is much stronger with the left-hand grip; dynamometer, left 59, right 45.

From the above facts it is evident that left-hand throwing is as a rule a sign of general left-handedness. It is not unlikely however that there may be exceptional cases, where this diagnosis may not be correct, e.g., injury to the right hand or arm at a critical age. On the other hand it is equally clear that throwing with the right hand is not always associated with right-handedness. Parents do undoubtedly effect the change, often at an early age.

(*c*) *Scissors test.*—The scissors in general use are made for right-handed people. In attempting to cut with the left hand anyone naturally holds them in the same way as he has learnt to do with the right hand, and if the two blades are loosely attached these are in consequence forced apart instead of together. The cutting of paper, linen, &c., is impossible under these conditions, especially if the scissors are not very sharp. This test seems to be a most reliable one with children, and especially with dull and backward ones. With adults however, it is different, as a great many have learnt to cut their nails with the scissors in their left hand. Many do not clearly understand how they do it, and a fairly high percentage cannot do it at all. It is often very difficult to teach them, and frequently after having learnt they find they have lost the knack, by merely cutting a piece of paper again with the right hand. Some left-handed children however can cut

a piece of paper only with their right hand with these scissors, but as a rule they can cut with the left or with both.

Children who can cut with these scissors with the left hand may be divided into two classes:—

(1) Those who can cut equally well with left and right hands.

(2) Those who can cut with the left but not with the right.

Among the youngest children—about 5 years of age in the ordinary elementary school, and about 7 to 8 in the mental defective school, there are many who cannot cut with these scissors with either hand, but are quite capable of doing so with the ordinary scissors in use in the schools.

A great many tests have been made with these specially prepared scissors, and the following results indicate their reliability. The scissors are merely loosened, and the cutting edge rendered less sharp by filing.

In the case of 318 children in mental defective schools, who cut with the left hand—

(i) 203 cut with left and right; of these, 172 were certainly left-handed (about 86 per cent.), eight had other indications of left-handedness, twenty appeared to be right-handed, and one appeared to be ambidextrous; the remaining two had been taught at home.

(ii) Fourteen cut with the left and could cut a little with the right; of these, fourteen were left-handed (100 per cent.).

(iii) 101 cut with the left only; of these, ninety-seven were left-handed (about 97 per cent.), two were probably left-handed, and two appeared to be right-handed, and no explanation of their skill was found.

Put in another way, out of 318 children who cut with the left hand 283 (89 per cent.) were left-handed, and nine (2·8 per cent.) were probably left-handed.

Below is given the percentage of left-handed children who cut with the left only, or with left and right hands:—

Number of left-handed children	Cut with left and right	Cut with left only
244	102 (41·8 per cent.) ..	78 (32 per cent.)

i.e., about 74 per cent. of the left-handed could cut with the left hand, and roughly speaking about a quarter could not cut with the left hand. Only very young right-handed children are unable to cut with these scissors with the right hand. All left-handed children, therefore, are not able with these scissors to cut with their left hand; in fact, only 75 per cent. can do so.

From these facts it is evident that (i) if a child can cut with these scissors with the left hand, and only with the left hand, he is nearly

certain to be left-handed, i.e., to use the left hand as the dominant hand in many of his activities.

(ii) If a child can cut equally well with both hands, he is probably left-handed.

(iii) If a child cannot cut with his left but can cut with his right hand, it must not be inferred without further evidence that he is not left-handed in many of his activities.

Attempts were made to discover how some of the markedly right-handed children had learnt to cut equally well with their left hand. In many cases no explanation could be found, and this is what might have been expected, as it is often difficult to obtain information from children found in mental defective schools. The following cases are interesting and are not unimportant when the whole question of left-handedness comes to be considered later on in this paper.

One boy explained that he never could cut with his right, and that his brother, who always cuts with his left and is left-handed, taught him. This boy is still unable to cut with his right hand, as he holds the scissors exactly in the same way as he does with the left, and so forces the two blades apart. In two cases the children who could cut equally well with either hand had been taught at home.

In elementary schools: (i) A girl, aged about 11 years, cut with both left and right hands, but asserted she had never been left-handed. On inquiry the head teacher of the infant school from which she came remembered quite distinctly that at first she used to write with her left hand; (ii) a girl, aged about 7 years, cut equally well with either hand, but in every other test gave no indication of left-handedness. It was then remembered that the girl had broken her right arm some time ago, and had come to school for three months with the arm in a sling. She was found to be able to write her name equally well with either hand.

(*d*) *Picking-up test.*—A large number of left-handed children pick up anything on the ground with their left hand, provided their attention is concentrated on the picking up and not on the question of the hand they are going to use.

Those to be tested were arranged in a line and a small piece of paper was placed exactly in front of each. They were told that there was to be a race to see who could pick up the paper first and hold it up.

It was found best to say: "Stand up straight with your arms down," and immediately afterwards, "Go." In many cases it was noticed that some left-handed children, when getting ready, placed their left hand

behind them, apparently to force themselves to pick up with the right. If however they were made to stand up straight with arms held down and started immediately, the left-handed picked it up quite naturally, and with the left hand. Sometimes children started to pick up with the left, and then suddenly changed to the right. Whole classes have been tested; about ten or so were tested at a time in the hall, and those who were holding the paper in the left hand kept back; these, when all the class had been tested, were each given a piece of paper and asked to place it on the floor, and they were then raced again. Under these conditions it was found that right-handed children did not often pick it up with the left, but that in a certain number of cases the left-handed picked it up with the right. The test by itself may not be of much value, but taken with the other tests it is by no means unconvincing.

(*e*) *Winding test.*—As a rule in winding cotton on a reel, one hand is used to hold the reel and the other to wind. Among right-handed people the winding is done by the right hand, and in the case of the left-handed by the left. Sometimes the winding is carried on by the hand holding the reel, in either case however the winding is done by the dominant hand. A few children and a good many adults move both hands while winding the cotton. In such cases a simple apparatus can be used to prevent the movement of the holding hand, and the time can then be taken for winding a yard of string by each hand by means of a stop-watch.

The following experiments show a much greater speed with one hand than the other: a left-handed boy, right = 5 seconds, left = 3 seconds; a right-handed boy, right = 5 seconds, left = 7 seconds.

One fact is very noticeable—the winding by the dominant hand is done chiefly by a wrist movement, whereas when done by the non-dominant hand, the action is from the elbow or even shoulder, i.e., an arm movement. Notice has already been called to a similar movement in writing with the non-dominant hand, and further reference will be made to similar peculiarities in the "line test." It appears therefore that the tendency of the uneducated and unpractised hand is that of an arm and not of a wrist and finger movement.

(*f*) *Line test.*—This is a quantitative test, but it was intended merely to give an indication of left-handedness, especially in cases of doubt. It can be carried out very rapidly and a whole class of even sixty can be tested at the same time.

Slips of paper were distributed to the class, on which to practise

making as quickly as possible a number of separate vertical lines of about $\frac{1}{4}$ to $\frac{1}{2}$ inch in length, first with the right and then with the left hand. The blackboard was used to demonstrate exactly what was to be done. After one or two minutes' practice, new slips of paper were given out, and it was explained that there was to be a race to discover who could draw the greatest number of lines in a given time. The children were told to write their names on the slips, and then to hold up their pencils in their right hand. It was explained that at the word "go" they were to start making lines as quickly as possible and to continue until stopped after fifteen seconds. At the end of fifteen seconds the following instructions were given rapidly: "Stop; put down your pencils, and turn over the paper." Exactly the same instructions were given in the test with the left hand. The test always aroused interest and amusement, especially when the left hand had to be used. The same procedure was used in mental defective and in ordinary elementary schools.

The results were often very convincing, but it was always necessary when the test indicated left-handedness to scrutinize carefully the lines made by each hand, as sometimes left-hand speed was clearly due to less care being taken in drawing the lines.

In some cases, however, especially among children in mental defective schools, no reliance could be placed on the results; many of these children were in fact quite unable to concentrate their attention even for five seconds; and after making a few lines these stopped and looked round to see how the others were getting on. It was interesting to see how nearly every one was anxious to do his best and show his skill. As has already been mentioned, the arm movement of the non-dominant hand was very noticeable. The test was found to be most useful among ordinary children of about 11 years of age and upwards, and among adults.

There was a great variability in the number of lines drawn, but it was evident that as a rule the older and more intelligent the child the greater was the number of lines, as might naturally have been expected. The proportion between the number of lines made by the right and by the left hand varied in every possible way, but in right-handed adults the number made by the right was always at least 29 per cent. more than that made by the left hand. Left-handed adults, who have from childhood written with the right hand, as a rule did about 6 per cent. more with the right than the left.

The results of some of these tests are given in percentages of the

number of lines made by the right hand over that made by the left. If a greater number is made by the left hand the percentage is marked by a minus sign, e.g., 50 per cent. indicates that the number of lines drawn in fifteen seconds by the right hand was 50 per cent. more than the number drawn by the left hand, and 50 per cent. (–) indicates that the number drawn by the left hand was 50 per cent. more than that drawn by the right. A higher percentage would therefore point to greater difference in "handedness."

(i) Line test—percentages for right-handed adults: 29 (two cases); 30 (two); 32; 36 (four); 39; 41; 43; 48; 51; 59; 68; 85; 96.

Note.—There was also a case of 21 per cent., but the "subject," who was very right-handed, had broken her right wrist a year ago, thus no doubt lowering the speed of this hand. Another teacher was noted as 80 per cent., and she had always considered herself ambidextrous; she had, however, quite lately injured her left thumb, which would account for a decreased speed with her left hand. A good many experiments have been made with other adults, and in no case, except those given below, was the percentage less than 29 per cent. for the right-handed.

(ii) Line test: percentages for left-handed adults, and for doubtful cases.—

(*a*) Known to be left-handed, but always write with right hand: 21; 13; 7; 6; 5; 4; 1; 0 (two cases); 2 (–).

(*b*) Doubtful cases:—

Twenty-three per cent. Thinks she is right-handed, but in dressmaking always cuts on the left side with left hand; draws equally well with left or right hand; always ties left-handedly.

Fifteen per cent. Does many things left-handedly; has always thought herself ambidextrous.

Five per cent. Did not know he was left-handed; always deals cards left-handedly; throws with left or right equally well.

Five per cent. Not known to be left-handed, but in boxing equally strong with left or right; kicks equally well with either foot; grip dynamometer: right hand 107 kilos., left 105 kilos.

Two per cent. Carves and draws equally well with left or right; left arm (ulna) an inch longer than right; had once suffered from injury to right hemisphere with temporary loss of use of left hand and leg, but with no speech defects.

The average number of lines in thirty-six cases was for the right hand 68·5, for the left 56·5. The greatest number for right hand 88, for left 87; the least number for right 39, for left 21.

(*g*) *Grip test.*—This is a well-known test to measure by means of a dynamometer the strength of grip of the right and of the left hand; a great many observations have been recorded by various authorities. The norms are given for boys and for girls at different ages in the "Manual of Mental and Physical Tests," by G. M. Whipple. The index of right-handedness, i.e., the percentage of strength of the left hand compared with that of the right, was found to range, for an ordinary group of school children, between 91 and 96 per cent. "However, occasionally right-handed children may have an index of strength exceeding 1·00, i.e., grip may be stronger with their left hand. According to Ardlicka, this tendency to have an index contrary to expectation is peculiarly evident in left-handed persons, so that he estimates that nearly one-half of bona-fide left-handed persons may have a stronger grip with the right hand."

The following quotation from the same book is of special interest in connection with the present investigation. "It is often asserted that degenerates tend to be left-handed. Wallin's averages for epileptics show a net preponderance of 0·5 kg. for general average in favour of the left hand, though by no means all his S.'s had an index above 1·00."

It was thought that the grip dynamometer would be very useful in diagnosing left-handedness, but the results were so varying and often so inconsistent with known facts, that little value could be placed on the results obtained by it, unless these were fully supported by other tests. No doubt its inefficiency is due in part to the instrument used, as it is ill adapted to the varying sizes of the children's hands and could not be adjusted. Also there was not sufficient time to allow each child to have as a rule more than one grip with each hand. The dynamometer was taken round to each child, and placed in his hand in the best position and he was told to squeeze as hard as he could. The result was then called out and recorded by the teacher. In this way every one was stimulated to do his best. As a matter of fact every child was eager to make the trial, and wished to try over and over again to improve his record. One curious result was noticed, namely, that in the first trial the two hand grips often approached very closely, not only among mental defectives, but also among normal children and even among adults. After practice the difference between the two hands becomes more marked, but even then it is by no means constant.

Some of the results are recorded in the tables of tests at different schools, but the results must be regarded with a good deal of suspicion.

(*h*) *Other tests.*—Many of the following tests have been tried, but

not very extensively. Generally they gave results agreeing with those obtained by the other tests, but only single individuals and those as a rule who were left-handed (or doubtful) were experimented with.

(i) Placing counters in a box one by one, two children being raced to see who could do it the quicker. As a rule it was done by the dominant hand.

(ii) Tying a knot in a piece of string: this was found to give very contradictory results, especially by those who had done "string" work at school.

(iii) Hammering nails and sawing wood, among the elder boys: if done left-handedly the boy was nearly always left-handed.

Taking the tests as a whole, the most unsatisfactory in the case of children in mental defective schools were those quantitative in character, and requiring attention and concentration. The tests which gave the most consistent and reliable results were those in which actions that had apparently become fixed by habit at some time in their early childhood were tested.

§ 2.—*Method of Testing Classes.*

(*a*) *In junior mental defective schools in infant schools and in Standards I and II of the ordinary schools.*—A list of children with their ages is given to the teacher, and each child is tested with the duster as has already been described. The teacher notes those who rub and throw with the left hand. Only those who rub with the left hand are at this stage tested in throwing. Each child is then tested with the scissors, and those who cut with the left are also tested with the right hand, the results being noted by the teacher. Any child found to cut with the left hand is also tested in throwing, if he has not been previously tested, and the result entered as left or right. Sometimes the dynamometer grip test is then tried; at other times the "line" test. Finally those indicated as left-handed in anything are raced in "picking up" and in "winding."

The teachers are then, and not till then, asked to give the names of those who write with the left hand, who used to write or who wished to write with the left hand; also those who draw with the left hand. If any of these have been missed they are tested in throwing, &c. Often in the case of very young children they are asked to draw something on their millboards, and a note made of the hand used.

Some examples of classes tested in this way are given in the tables.

(*b*) *In elder boys' and girls' schools.*—A list of children with their ages is made as in the infant schools, and the teacher records the results. The first test is the "throwing" test, which is followed by the "line" test. In Standards V, VI, and VII this latter test takes very little time, as after the lines have been drawn the children are asked to count the number made by each hand and enter it on the slip. The teacher then calls out each name, and the children read out the number for the right and for the left hand. The slips are collected for scrutiny and verification; they are especially examined in those cases where the number of lines approach each other, or where the lines made by the left hand are more numerous than those made by the right. Each child is then tested with the scissors. Those who appear to have indications of left-handedness are further tested with the "picking up," and "winding" tests. Sometimes the dynamometer is used in addition to, or in place of, the "line" test. Information as to the hand used in writing is then obtained. Examples of the results recorded in classes for older children are given in the tables.

The tests which have just been described appear to be more suitable for children in mental defective schools than quantitative tests (e.g., as tapping, &c.),[1] as the latter involve attention and concentration, both of which are difficult to obtain from these children. In addition, much time and care is required in using them, and the children's skilfulness is only proved in one or two special kinds of work. The qualitative tests, on the other hand, reveal much of the past history of the child, and give evidence of habits, natural or acquired. As a matter of fact, very few were missed who were known to be left-handed, or perhaps it would be better to say, who were known to write or to have written at one time or another with the left hand. In many cases left-handed children were discovered who were not known by their teachers to be left-handed, but who on inquiry were proved to have been left-handed at school or at home. One thing also became clear, namely, that there were all grades of left-handedness. There were some indeed who did everything left-handedly; others who did most things left-handedly, and again others who were right-handed in most of their activities, but had some clearly marked left-handed habits.

At first sight these conclusions may seem to depreciate the value of the tests, but it will be found that the results of the tests are by

[1] "Shot tube" test, that is, dropping steel balls into a vertical glass tube, and comparing times taken by each hand. "Pegboard," in which pegs are fitted into holes, and the times taken by each hand compared.

TABLE I.—SCHOOL, MENTAL DEFECTIVE: CLASS 1.

Names	Ages	Rub	Throw	Cut	Pick up	Wind	Write	
Boys—	Yrs. mths.							
1	12 0	..	..	..	..	..	..	..
2	14 3	L.	L.	L.R.	R.	L.	R.	Always cuts with left at school
3	10 1	..	..	..	..	..	..	..
4	12 1	..	..	..	..	..	..	..
5	9 9	L.	R.	L.	R.	L.	R.(L.)	..
6	11 3	..	..	..	..	..	..	..
7	11 10	L.	L.	L.R.	L.	L.	L.	..
8	12 0	..	..	..	..	..	..	..
9	11 5	..	..	..	..	..	..	..
10	11 4	..	..	..	..	..	..	..
11	11 4	..	..	..	..	..	..	..
12	12 6	..	..	..	..	..	..	..
13	11 5	..	..	..	..	..	..	..
14	11 2	..	..	..	..	..	..	..
15	11 0	..	..	..	..	..	..	..
16	9 5	L.	L.	L.	R.	L.	R.(L.)	..
17	11 4	..	..	..	..	..	..	..
Girls—								
1	12 3	L.	L.	L.R.	L.	L.	R.(L.)	..
2	14 0	..	..	..	..	..	..	..
3	9 5	..	..	..	..	..	..	..
4	9 5	L.	L.	0*	L.	?	R.(L.)	..
5	9 9	..	..	..	..	..	..	..
6	9 3	L.	R.	0*	L.	?	R.(L.)	..

(1) All were tested in rubbing and in cutting, only those indicated as left-handed were further tested in "picking up" and "winding."

(2) All were tested in left-hand writing; no mirror writers.

(3) Under "write" are given the hand habitually used in writing: (L.) indicates that these children were known at the school to have written, or to have wished to write, left-handedly at some period of their school life.

(4) Under "wind" ? indicates that both hands were used at the same time, and that it was therefore impossible to decide which was the dominant hand.

(5) Under "cut" L. = could cut with left *only;* L.R. = could cut equally well with left and right; L.(R.) could cut with left and not at all well with right.

(6) * = not tested in this, e.g., right-hand cutting.

TABLE II.—SCHOOL, MENTAL DEFECTIVE: CLASS 2.

Names	Ages	Rub	Throw	Cut	Pick up	Wind	Write	
Boys—	Yrs. mths.							
1	8 11	..	..	..	..	..	..	..
2	10 5	..	..	..	..	..	..	..
3	9 7	..	..	..	..	..	..	..
4	9 10	..	..	..	..	..	..	..
5	10 6	L.	L.	L.	L.	L.	L.R.	Speech indistinct; *has* written mirror
6	8 8	L.	L.	L.R.	L.	L.	L.	Decided epicanthus; *has* written mirror
7	7 11	..	..	..	..	..	..	..
8	7 10	..	..	..	..	..	..	..
Girls—								
1	10 8	L.	L.	L.	L.	L.	L.	Defect of articulation; *has* written mirror
2	9 7	..	..	..	..	..	..	..
3	8 3	L.	L.	R.	L.	R.	L.	Very backward and babyish
4	12 7	..	..	..	..	..	..	..
5	8 4	..	..	..	..	..	..	..
6	10 7	..	..	..	..	..	..	..

no means unimportant, when the reason for the larger number of left-handed children in mental defective schools comes under consideration.

In deciding whether a child should be classed as left-handed—in estimating percentages—the following tests as a rule were taken as sufficient:—

(1) Persistent rubbing and throwing with the left hand, especially among very young children; these nearly always also wrote with the left hand.

(2) Throwing and cutting with the left hand.

(3) Writing or having persistently written at one time with the left hand.

TABLE III.—SCHOOL—MENTAL DEFECTIVE, ELDER BOYS: CLASS 2.

Names	Ages		Throw	Scissors	Dynam.		Pick up	Wind	Write	
					L.	R.				
Boys—	Yrs.	mths.								
1	14	4	..	..	40	49	..	..	..	..
2	13	1	..	..	66	75	..	..	..	Best boy but difficult to control
3	14	1	..	..	50	51	..	..	..	..
4	14	3	..	..	10	13	..	..	..	Fairly intelligent. Attending hospital
5	14	7	L.	L.R.	47	54	L.	L.	R.(L.)	Fairly intelligent
6	14	11	..	..	41	28	..	..	..	..
7	14	2	..	..	43	47	..	..	..	..
8	13	9	L.	L.	45	36	L.	L.	L.	Fairly intelligent
9	13	9	..	..	44	40	..	..	..	..
10	13	10	..	..	48	40	..	..	..	..
11	15	1	..	..	35	35	..	..	..	..
12	13	8	..	..	31	29	..	..	..	..
13	13	7	..	..	18	20	..	..	..	..
14	15	11	..	..	30	31	..	..	..	..
15	14	0	..	..	34	39	..	..	..	..
16	13	4	..	..	40	38	..	..	..	..
17	14	3	..	..	33	33	..	..	..	..
18	14	5	..	..	24	30	..	..	..	..
19	16	8	..	..	49	55	..	..	..	..
20	15	3	R.	O.*	38	38	R.	?	R.	*Mirror* writer; very slow. Chorea at one time

Note.—All tested with scissors, throwing and dynamometer; in the other tests only those indicated were tested. All tested in left-hand writing.

Children who could cut with the left hand, but displayed no other left-handed activities, were classed as right-handed. In many cases, however, further inquiries were made into their past history. Children who merely "pick up" or "wind" or do both, were not included among the left-handed. The dynamometer and "line" tests were only used as confirmatory tests. In the great majority of

cases, especially in mental defective schools, there was little or no difficulty in coming to a decision. In doubtful cases the children were classified as right-handed.

When it appeared that the percentage of left-handed children in mental defective schools was very much higher than had been found by various authorities among normal children and adults (4 to 6 per cent., and sometimes higher), it became necessary to apply the same tests to the children in the ordinary elementary schools. The same methods were used—one set of tests for children up to about 9, and the other set for older children. As will be seen by the results, the percentage was very much lower than that in the special schools, and somewhat higher than had been estimated by the majority of authorities.

Chapter III.—Results among Normal and Mentally Defective Children.

Among normal people, Ogle found 4½ per cent. left-handed in 2,000 cases; G. M. Gould gives 6 per cent.; Franklin Jones, 4 per cent.; H. Macnaughton Jones says: "Ghent University had 22 per cent. left-handed (100 cases), but generally the left-handed are estimated at 1 per cent. to 2 per cent."[1] Malgaigne (1859) 8 per cent. to 10 per cent.; Hecht and Langstein (1900), even 12 per cent.; Masini (1907), 10 per cent.; Songues (1,080 cases), 7 per cent., left-handed and ambidextrous; Moutier, at least 10 per cent.

Ballard, in "Sinistrality and Speech" (1912), gives 4·1 per cent. as the result of data obtained from the teachers in reference to children in elementary schools in London. The number of children dealt with was 13,189, and the ages between 4 and 14 years. This percentage is considerably lower than that (7·3) found in elementary schools in Middlesex and London during the present investigation; the number, however, actually tested was only 3,298, and the ages between 4 and 14 years. In his own personal inquiry, however, Ballard reduced the percentage to 2·8; 11,393 cases, and ages between 8 and 14 years. This reduction is remarkable. It seems possible that the omission of the infant schools may have been the cause of the difference in percentages. It is possible that left-handed children may have been over-

[1] Josefa Ioteyko, late of Brussels University, states (1917) that there are a considerable number of left-handed in Belgium much above the general estimate of 2 to 3 per cent. [10]

looked in the senior schools, owing in part to a forced change in writing.[1]

To discover whether anything of the kind had occurred in the present inquiry, the percentage of left-handed in Infant schools and in Standard I was compared with that in Standard II and upwards, with the following results :—

	Number tested	Number of left-handed	Percentage
Senior schools, Standards II to VII ..	934	77	8·2
Infant schools, and Standard I ..	910	64	7·0

In the estimates of left-handed people the outstanding feature is their great variety. There can be little doubt that percentages in a subject of this kind are very misleading, and that they are of little value unless large numbers are dealt with. The present inquiry has clearly shown how greatly classes and schools differ from one another; for example, in one class of a school 20 per cent. were found to be left-handed, and in another class in the same school there was none. In one class of a mental defective school 66 per cent. (14 out of 21) were clearly left-handed, whereas in another school of the same kind there were only 1 to 2 per cent. Apart from this, different methods give very different results. In fact left-handedness has always been very difficult to diagnose. Personal interviews are very misleading and inaccurate; children are as a rule very unwilling to acknowledge left-handedness and have frequently forgotten all about it, even in cases in which they still use the left hand as the leading hand in many of their activities. The older the " subject " the more difficult is the diagnosis. As a matter of fact many undoubted left-handed adults are convinced that they are ambidextrous. The question naturally arises as to how we are to define left-handedness. Moutier suggests that a left-handed person is one who habitually does with the left hand a series of professional and usual acts generally done by the right hand in the case of the right-handed, and that the ambidextrous are those who do these acts with either hand indifferently. In the present investigation, a definition of a very similar character was the basis of the diagnosis of left-handedness, although the work of Moutier on aphasia had not been seen until almost the end of these experiments and observations. Although this definition is open to criticism, it has, I think, been fruitful in suggesting experiments and inquiries, which have not been altogether barren of results.

[1] Schäfer (1911) [23], in an investigation by questionnaire, concludes that the percentage of left-handed is higher among boys than girls, and that it diminishes at each age.

Results of tests :—

Schools	Number tested	Number found to be left-handed	Percentage
(1) Elementary schools, ages 4 to 14 ..	3,298 ..	241 ..	7·2
(2) Mental defective schools, ages 8 to 16 ..	4,620 ..	843 ..	18·2

There appears, therefore, to be more than two and a half times as many left-handed children in mentally defective schools as in ordinary schools.

To discover whether there was any great difference in the percentages of left-handed boys and girls in these special schools, 729 cases were taken haphazard with the following result :—

PERCENTAGE OF LEFT-HANDED BOYS AND GIRLS.

	Number tested	Number found to be left-handed	Percentage	Percentage boys and girls
Boys	374 ..	61 ..	16.6 ..	18·7
Girls	355 ..	76 ..	20·7 ..	

These numbers are not very large, but they appear to represent about the proportion generally found. The proportion of girls to boys as found above is therefore as five to four, in other words the left-handed girls are about 25 per cent. more numerous than the boys. J. W. W. Wallin (1915-16) [26] found by questionnaire the percentage of left-handed among boys 3·6 and among girls 2·1. The number of pupils dealt with was 89,057.

Whether the above percentages are reliable or whether they are too high, one thing is clear to anyone visiting both special and ordinary schools, namely, that there is a very much higher percentage of left-handed children in the special schools, no matter what method of estimating the number is used, whether by merely noting those who write and work left-handedly, or by testing to discover in addition those who were at any time left-handed and have been converted into right-handedness in many of their activities, such as writing, throwing, sewing, knitting, &c.

Some very high percentages were found in some of the classes and in whole schools, as is shown by the following percentages of left-handed children in certain classes, and in whole schools (mental defective).

53 per cent. (47); 45 per cent. (19); 44 per cent. (61); 33 per cent. (27) (39); 31 per cent. (19); 29 per cent. (17). For whole schools: 2 schools over 30 per cent.; 5 schools 25 to 30 per cent.; 13 schools 20 to 25 per cent.; 12 schools 15 to 20 per cent., &c.

The numbers in brackets are the actual numbers tested. In no case was a class specially selected.

In ordinary schools the percentages varied very considerably in different classes. Sometimes the whole school was tested, but generally a few classes were chosen haphazard. The percentages were as a rule between 4 and 10 per cent. In three cases the classes were specially tested owing to the known high percentage, e.g., (i) a backward class gave 15 per cent., whereas three other classes in the same school gave 5 per cent., 3 per cent. and 3·5 per cent.; (ii) Standard Ia with 22 per cent., two other classes in the same school gave 3 per cent. and 6 per cent. respectively; (iii) Standard II with 13 per cent., whereas Standard I gave only 2 per cent.

From these results the question naturally arises: Why are there so many more left-handed children in mental defective schools? The answer to this question will be left for the present.

Chapter IV.—Twins and Left-handedness.

In an elementary school two girls (twins) 14 years of age and nearly identical in all their characteristics—school work, appearance, &c.—were found on testing to be, one thoroughly left-handed, the other right-handed. On the next day in a mental defective school, twins—boy and girl—gave the same results, i.e., one left-handed, the other right-handed. Sometime later, it seemed probable that an investigation on the "handedness" of twins might throw some light on the hypothesis suggested later in this paper. There appear to be two kinds of twins —the one being derived by the fertilization of a single ovum, the other from the fertilization of two distinct ova. In the first case the twins are stated to have exactly the same characteristics, and it seemed that it would therefore be possible to decide whether left brainedness was one of these characteristics. As will be seen by the facts given below, it is by no means so simple a question as appears at first sight, as it is quite possible that the two twins may originally have been "identical," but that one may be very unlike the other in some of the characteristics (such as height, mental capacity, &c.) owing to some accidental cause.

Galton [8] in speaking of twins states that "the word twins is a vague expression, which covers two very dissimilar events—the one corresponding to the progeny of animals that usually bear more than one at birth, each of the progeny being derived from a separate ovum, while the other event is due to the development of two germinal spots

in the same ovum. In the latter case they are enveloped in the same membrane, and all such twins are found invariably to be of the same sex."

The following results were obtained from 219 pairs of twins, most of whom were in ordinary elementary schools. They were all tested in the usual way described in this paper.

TWINS.

Sex	No.	Both Right-handed	Both Left-handed	One Right, other Left-handed
Boys ..	59	47	0	12
Girls ..	79	69	1	9
Boy and girl	81	53	3	25 (i.e., 11, boy R. and girl L.; 14, girl R. and boy L.)
Total ..	219	169	4	46

It is remarkable that in the mixed twins (boy and girl) nearly one-third the number consists of the one right-handed and the other left-handed. As to ability, appearance, &c., about 66 per cent. both of boys and of the girls are very much alike, when both are right-handed, and 33 per cent. are very dissimilar.

Some curious facts were noticed in the case of twins, one of whom was left-handed and the other right-handed, facts which are shown in the following table of comparison of the left-handed twin with the right-handed. The notes as to ability and physical defects were obtained from the teachers before the tests were made.

It will be noticed that in eight cases the left-handed twin is mentally defective and the right-handed is in an ordinary elementary school. Hitherto no case has been reported of the right-handed twin being in a mental defective school and the left-handed in an ordinary school. Not infrequently both right-handed twins are in a mental defective school. In twelve cases the left-handed twin is very nervous, much shorter, or more retarded compared with the right-handed.

It is possible with some of the twins (left and right-handed)—

(1) Especially where both are quite normal, that the left-handedness of one may be due to some accident as given in the note (p. 335), or

(2) Where the right-handed is much retarded, that they were originally both left-handed, e.g., in case of chorea, &c.

COMPARISON OF TWINS, ONE OF WHOM IS LEFT-HANDED, AND THE OTHER RIGHT-HANDED.

Both Boys.

	The left-handed twin	The right-handed twin
1	Very nervous	Normal
2	Very nervous, cries, shorter, less intelligent	,,
3	Normal	Rather retarded (a brother is left-handed)
4	Very short, in Standard IV	Very tall; in Standard IV
5	Left eyelid droops; in Standard IV	In Standard V
6	Healthy; average ability	Rather dull; adenoids and nasal catarrh
7	In mental defective school; defective speech	Died at 9 years of age; ordinary school
8	In mental defective school; hesitates in speech	In Standard IV
9	In mental defective school; 15 years old	Was in mental defective school; allowed to leave at 14 as much progress made

Both Girls.

1	Normal (very alike)	Normal
2	Dull	Dull; chorea
3	Much shorter and more babyish	Ordinary
4	In mental defective school; 8 inches shorter than sister, and much less developed	In mental defective school

Boy and Girl.

	Girl left-handed	Boy right-handed
1	Very slow; "peculiar speech"; improving, now writes right-handed	Normal
2	Chorea	,,
3	In a mental defective school	,,
4	Examined for mental defective school; on probation; very small	Normal, small
5	Below average intelligence	Dull
6	Very bright	Comparatively dull
7	Normal	Normal
8	Good ability; shorter, delicate; glandular abscess in neck and leg	Better ability than sister
9	Standard V	Standard VII; suffers from heart
10	Backward; lungs affected	Very bright

	Boy left-handed	Girl right-handed
1	In mental defective school	In mental defective school
2	,, ,, ,,	Below normal
3	,, ,, ,,	Fairly intelligent
4	Above normal	Above normal
5	Average ability	Below average ability
6	Not so bright as sister	The brighter
7	Normal; left eye squint	Normal
8	Standard VII	Standard V
9	In mental defective school; very defective speech	Standard V
10	In mental defective school	Standard VI; delicate
11	Much shorter than sister in infant school	Under-sized; in infant school

Note—In the statistics given are included all the twins in elementary and mental defective schools, who have been tested. Among the twins classified as both right handed were:—

(1) Both girls, in an infant school, one did most things left-handedly, but she was right-handed until she broke her arm three months previously.

(2) Both girls, aged 13½ years: one left-handed in everything except writing. She was right-handed until she burnt the palm of her right hand three years ago; she has only just recovered, the palm is very badly scarred.

Chapter V.—Mirror Writing.

As has already been mentioned, many children in mental defective schools were found to write mirror fashion when writing with their left hand, and as this kind of writing was prevalent in these schools, various experiments and inquiries were made in reference to the matter. The ages of the children who wrote mirror fashion varied greatly—from about 10 to 16 years ; younger children could not as a rule be tested, as they were not able to write their names. With one or two exceptions the mirror writers were right-hand writers, but it was remarkable that the left-hand mirror writing of most of these children was much better than their ordinary writing with the right hand.

As a matter of fact, the mirror writing in the case of 56 per cent. was very good indeed, of 29 per cent. good, and 7·5 per cent. fair, and of 7·5 per cent. bad.

57 per cent. started at the right-hand edge of the paper, 13 per cent. in the middle, and 30 per cent. towards, or not far from, the left margin—the usual place of beginning in ordinary writing. At first, there seemed to be a close connection between the act of mirror writing and the starting position ; e.g., one began correctly, but after writing the first letter, which was at the extreme edge of the paper on the right, finished mirror fashion. Another began at the extreme right edge and wrote each letter correctly, but from right to left, i.e., backwards.

Some began mirror fashion, and apparently noticed that something was wrong, and then tried to correct themselves ; in some cases successfully, but in others without success, even after trying two or three times. Their hand appeared to be doing exactly the opposite to what they wished. The majority were unable to read what they had written, but many could read an easy word, such as " cat " written mirror fashion. As a rule, the writing was done very rapidly and without hesitation, even by the very " low grade " feeble minded. But there were other cases where it was evident that the child was following carefully with the eye every letter, and it seemed certain that the letters were being formed in exact accordance with an optical mental image formed at the time. Generally the writing in these cases was slow, but it was well done. How remarkable this mirror writing is can be easily understood when it is explained that intelligent and capable teachers, who have not practised mirror writing, find great difficulty in writing in a " running hand " a capital (not printed) G or L mirror fashion, and

yet these very mentally defective children could do it without any difficulty or effort.

A few print their names (mirror fashion), but as a rule the writing looked at in a mirror is very similar to the ordinary writing of the child. In one or two cases the name is printed with the right, and written in a "running hand" mirror-fashion with the left; these latter cases are in schools which have lately taken up "print writing."

One boy, a left-hand writer, wrote mirror fashion with his right hand. There were there cases of the same kind, and also mirror writing with the left hand by children who habitually write with the same hand.

Various experiments were made with the children who wrote mirror fashion, e.g., they were asked to write "cat," "10," "25," &c., with their left hand and then with their right. In most cases, the left-hand writing was mirror fashion, and the right in the ordinary and correct way. Sometimes the right-hand writing was done first, but the results were the same, namely, mirror writing with the left.

Again, others were asked to write "cat," "dog," "45," with the right hand, and then to copy them underneath with the left; the result was the same. The writing was done as a rule without any hesitation, and with rapidity. A word, e.g., "cash," was written mirror fashion, and some of these children were asked to copy it underneath with their right hand; they generally copied it correctly, i.e., not mirror fashion; on being asked to copy what they had just written, but to do it with the left hand, they wrote it mirror fashion. In one experiment the word "illustrate" was written mirror fashion in a running hand by the experimenter. The child could not read it, but when asked to copy it with her right hand she immediately wrote the word correctly (not mirror fashion) in every detail.

There are a few letters and figures which are frequently written mirror fashion by young children, especially s, d, b, 4, 6, and 9, but this writing is undoubtedly different from the mirror writing under discussion, and may be due to the lack of accurate observation on the part of a child, and never seems to extend beyond single letters and figures; but of course correct writing with one hand and mirror writing with the other is due to some other cause.

At one school, a little girl (D. E.) copied in print a whole page from a book mirror fashion, with the exception of "a" and "e"; she had never done this before, and she had not done it since. She was tested in the usual way with others in the class; she "rubbed," "threw," and "wound"

with her left hand, but "picked up" with her right, and could only "cut" with her right; her "grip" was 2 kilos with each hand; she has a "peculiarity" in her speech. On thinking the matter over, it seemed probable that she had done the copy with her left hand, so at the next school, where two mirror writers were found in one class, they were both asked to copy out a page from a book, and to do it with the left hand. They were both right-hand writers, but they made the copy rapidly—one was well and correctly written, the other was well written, but every letter and word was written mirror fashion. This girl (E. A.) aged 14, is hydrocephalous and very defective; she "threw," "picked up," and "wound" with her left, could "cut" with either hand, her "grip" was 12 kilos with each hand,[1] but she always "rubbed" with her right hand. At a subsequent visit to the first school, the little girl (D. E.) was asked to copy some lines from a book with her left hand, and to begin at the right-hand corner. She immediately wrote her name mirror fashion, and then wrote a whole line in a similar way. When she reached the end of the line, i.e., at the left-hand margin of the paper, she asked whether she should go back the other way, that is, starting just under where she had finished. She then wrote this line quite correctly, not mirror fashion. The same experiment was tried with her right hand, only she was asked to begin in the middle of a line. She wrote correctly until she reached the end of the line, and was then asked to go on writing from the position just under where she had finished; without any hesitation she wrote this line mirror fashion with her right hand. This little girl was 9 years 2 months old. The doctor reported when she was examined (aged 8 years 8 months): "Talked at 5 years; walked at 2 years. Defective articulation: left-handed." Until three months ago she used to write with her left hand, but not mirror fashion. After a few months writing with her right hand, she writes mirror fashion, when she reverts to her left hand. Further, she now writes mirror fashion with her right hand when she is started at the right edge of the paper. It would therefore appear that in her case at all events the change in writing from one hand to the other may have had something to do with the peculiar kind of writing. As will be shown later (p. 342) a very high percentage of children, who have at one time written with the left hand but now write with the right, write mirror fashion when asked to write their names with the left hand. It is important to note that this girl did not write mirror fashion when she first began to write with her right hand, but that it was only after she had practised writing with her left and also with her right hand. The importance of this fact will be understood when the hypothesis suggested by Baldwin is considered (p. 353).

Subsequently it was found, especially in the case of children, who at one time had written mirror fashion, and of others who sometimes write with the left hand, and at other times with the right hand, that they can be made to write mirror fashion by merely asking them to

[1] Normal grip for a girl of this age: right 24·79, left 22·92 kilos.

begin at the extreme right margin of the paper. The probability of such a result only suggested itself quite lately, so only a few experiments have been made. Teachers were asked for the names of children who sometimes write with the left and sometimes with the right hand. The following results were obtained from a few children selected in this way.

H. N., boy, aged 8. The doctor reports: "Speech defective. Father epileptic (?), and cannot read or write." The boy when asked to write his Christian name with his left hand beginning at the extreme right edge of the paper, wrote in mirror fashion without any hesitation. He wrote his name correctly with the same hand, when asked to begin at the left margin of the paper. With his right hand he did exactly the same, i.e., mirror fashion at the right edge, and correctly at the left. There was, however, one peculiarity in all the four written names, namely, the correct writing (not mirror fashion) of the final "y" in his name (Henry). At another school very similar results were obtained with a left and right hand writer. This boy with his left hand wrote his name completely mirror fashion without hesitation when started at the right margin, also "cat," but "25" correctly; with his right hand, however, under the same conditions, he hesitated and seemed to find some difficulty in beginning, but finally wrote his name completely mirror fashion. At the left margin, he wrote his name correctly with either hand. Other experiments were made with left-handed children, but some of them could not be induced to write mirror fashion with either hand, when asked to begin at the extreme right margin, as they insisted on edging off to the left and then wrote their names in very small letters, so as to get them into the only available space. Other mirror writers (with left hand), many of whom wrote mirror fashion wherever they were started, could not be induced to write mirror fashion with the right hand under any circumstances.

Another interesting case was that of a boy (H. W.), left-handed in writing and in nearly everything else, except throwing, who wrote all letters and numbers correctly with his left hand, but wrote them mirror fashion with his right.

A curious case was met with at another school. A little girl (L. C.) wrote a word correctly with her left and mirror fashion with her right: she was asked to write another word first with her right—she wrote it correctly; but she wrote it immediately afterwards mirror fashion with her left hand. She is 12 years 9 months old: throws left, cuts left only, winds left and writes left. The doctor reports: "Infantile paralysis, right hemiplegia, used to write mirror fashion with her left hand; gave it up in 1916 (i.e., about 8 years of age), but reverts to it at times in 1917." At a second visit she printed her name completely mirror fashion on the blackboard with her right hand when asked to begin at the right-hand corner.

Early in the investigation it was noticed that there was a much higher percentage of mirror writers among children, who, although

they wrote with the right hand, were evidently left-handed in many others of their activities. This fact has been noticed by previous investigators. Ballard (1916), referring to mirror writing, says: "With rare exceptions it is done by left-handed people only, and with the left hand only. . . . The subject does not at first recognize the word as he writes it down; nor can he without some practice read it. . . ." [4].

A. L. Beeley (Instructor in Psychology, Utah University), after an investigation in schools of Chicago in 1918, came to a similar conclusion, namely, that mirror writing is "a characteristic of extreme left handedness," and "not necessarily of mental deficiency." Ireland [11], 1881, connected mirror writing with left-handedness.

As mirror writing appeared to be associated with left-handedness, many left-handed adults were asked to write their names with the left hand, but they always did it correctly. In one case, however, it was noticed that the pencil seemed instinctively to have been placed at the right-hand edge of the paper, and then withdrawn and the writing begun at the usual place—left margin—without the "subject" paying much attention to what she had done. An experiment was next made with a left-handed teacher, a capable and intelligent head-mistress. She was asked to write her name with her eyes shut; she did it rapidly with her right hand, and quite as well as with her eyes open. She was then asked to close her eyes, and write her name with her left hand; she did so immediately but mirror fashion. When she looked at it, she could not make out what she had written, and said, "What is the matter with me?" When the paper was held up to the light—the reverse side—an excellent copy of her name in her ordinary writing was seen. She explained that she was quite sure she was writing it in the ordinary way.

Similar experiments with a few other left-handed teachers were made, and in one case with exactly the same result. In fact the latter, a capable and intelligent assistant teacher, made nearly the same remarks as the first. In still another case, although the teacher wrote her name correctly with her left hand, she stated that while writing it she thought at times she was writing it "backwards." A few left-handed adults who write with the right hand were found to be able to write mirror fashion without any difficulty with the left hand, although they had not made the attempt before. Others—right-handed or left-handed—have to concentrate their whole attention on what they are attempting, and even then make mistakes.

McHattie (1913) [20] describes some experiments he made in London elementary schools in connection with mirror writing. He found in the left-hand writing of 1,240 children, ages 7 to 14 years, that there were only seven cases (0·48 per cent.) of mirror writing. One was a girl, she was not included in the percentage, whose right hand had been partially disabled by infantile paralysis, and could not write with this hand. The percentage was about twice as high with the boys as with the girls.

In the present investigation 829 children were tested in left-hand writing in the ordinary elementary schools (infant and senior departments), and only four (0·48 per cent.) were found to write mirror fashion. The total numbers in both cases are small, but they agree very closely, and it appears likely that the percentage (0·4 to 0·5) is not far wrong. A. L. Beeley [6], in elementary schools in Chicago in 1918, found in 103 schools with a school population of 106,356, forty-two mirror writers—i.e., about 0·04 per cent. In his investigation, however, he did not test the left-hand writing of every child, but only asked for information from the teachers concerning all children who had been observed to write mirror fashion at any time in their lives. There was about the same percentage of mirror writers among the boys as among the girls.

The percentage of mirror writers in mental defective schools in London and Middlesex is given below:—

Number of children treated	Number of mirror writers	Percentage
1,350	109	8·0

These numbers include both boys and girls of varying ages from 8 to 16 years, generally about 8 years of age and upwards, as only those who could write their names were tested. Mirror writing of isolated letters and figures—such as 3, b, d, 4, 6, 9—is not included in the above percentage. It is evident, therefore, that mirror writing is very much more prevalent among the feeble-minded than among normal children; the percentage is in fact about seventeen times as great.[1]

A still more striking result is obtained from the calculation of the percentage of mirror writers among left-handed children.

The following statistics have been carefully made out in the case of mirror writers, who had all been tested in "handedness."

[1] In one school thirty-one were tested, and there were ten mirror writers—a most remarkable result. It seemed possible that the mirror writing might have been due to some special methods of instruction in writing, drawing, physical exercises, &c., but after careful investigation it was evident that the methods used were the same as those used in other special schools.

MIRROR WRITERS AMONG LEFT-HANDED CHILDREN.

Sex	Number tested in left-handed writing	Number found to be left-handed	Number of mirror writers among left-handed	Percentage of mirror writers among left-handed
Boys ..	374	61	11	18
Girls ..	355	76	30	40
Boys and girls	729	137	41	30[1]

That is to say, 30 per cent. of the left-handed children were mirror writers, and in the case of girls the percentage reached the astonishing number of 40 per cent.

Further the mirror writers were nearly always left-handed children, who wrote with the right hand. These percentages were further analysed with the following results: 40 per cent.[2] of these left-handed boys habitually write with the left hand, and 60 per cent.[3] with the right hand.

Of these left-handed boys who write with the right hand 32 per cent. wrote mirror fashion with the left.

Curiously enough the same percentage (i.e., 40) of girls write habitually with the left and 60 per cent. with the right hand.

Of these left-handed girls who write with the right hand, 62 per cent. wrote mirror fashion with the left. The majority of mirror writers have, therefore, at one time or another written with the left hand; and it would seem that, this being the case, they would be less likely to write mirror fashion than children who had never co-ordinated their left-hand movements to the usual forms of letters and words.

It is therefore evident that mirror writing is very closely associated

[1] The percentage of right-handed children (i.e., children who gave little or no indication of left-handedness in the tests) who wrote mirror fashion with the left hand, was of boys 1·6 per cent. and of girls 2·8 per cent.

[2] To see whether this result gives a fair estimate, a larger number was taken: of 251 found left-handed 106 habitually write with left = 42 per cent.; 51 are known to have written left = 20 per cent.; 94 are not known to have written left = 38 per cent.

[3] There is a peculiar coincidence in connection with the children in mental defective schools who habitually write with the left hand. As has already been stated (p. 332) 18·2 per cent. of the children in mental defective schools were found by the various tests to be left-handed and, as it is estimated above, 40 per cent. of these are left-hand writers; it therefore follows that 7·2 per cent. of the children in mental defective schools write with their left hand—a number almost identical with percentage of left-handed children in ordinary elementary schools—namely, 7·3 per cent. (see p. 332). It seems, therefore, not unlikely that many of these (7·2 per cent.) may be the "naturally" left-handed children—children whom it has not been found possible to change into right-hand writers.

with mental deficiency,[1] and also with such left-handedness as has been brought to light by the tests already described. It is also clear that mirror writing is not itself due to mental deficiency alone, as only 8 per cent. of the feeble-minded write mirror fashion, nor is it due to extreme left-handedness alone, as very few left-handed children in ordinary and in physical defective schools write mirror fashion. Further, it does not seem impossible that the same cause may in some cases have brought about left-handedness and also mirror writing; that in fact something may have affected the dominant (in these cases the left) hemisphere. It may have been a lesion, causing among other things slight hemiplegia, or it may have been due to defective development of the dominant hemisphere. It would then follow that such left-handedness differed from what is usually termed "natural" left-handedness.

It is very necessary, therefore, at this stage to consider more carefully what is meant by "left-handedness," and also its various forms and their causes.

There has been much discussion and controversy, since Broca's investigations on aphasia, as to whether there is a dominant side of the brain, and whether its dominance is indicated by left or right-handedness. The origin of the controversy arose from observations of a large number of cases of aphasia associated with right hemiplegia, especially paralysis of the right hand, and of a much fewer number with left hemiplegia. Whether the motor speech centre is located in the third frontal convolution, as suggested by Broca, or in the lenticular zone as contended by Marie, or elsewhere, it is unnecessary to discuss in this paper. But it is agreed upon by all that in the majority of cases it is located in the left hemisphere, and further it appears to be held by most authorities at the present day that not only is the speech centre, but that also other important language centres are located in the dominant hemisphere: for the right-handed in the left hemisphere, and for the left-handed in the right.

Moutier in 1906, however, contended that the percentage of cases of left hemiplegia associated with aphasia was much less than ought to have been the case, if this theory was true; and in addition he cites six cases where the aphasia was associated with hemiplegia of a kind opposite to the known handedness of the patient. Moutier's

[1] A. L. Beeley [6], as already mentioned, considers that mirror writing is not necessarily a characteristic of mental deficiency. This is no doubt true, but it is certainly more prevalent among feeble-minded than among normal children.

estimates, however, of the percentage (10-12 per cent.) of left-handed are much higher than those usually recorded. In the cases he has collected (1864-1907) and given in his book, the percentage of cases of aphasia associated with left hemiplegia appears to be about 8·0 per cent. (total cases 347, 318 aphasia with right hemiplegia and 29 with left hemiplegia). He also quotes the following results as given by Hammond (1871): 17 cases of aphasia with left hemiplegia (i.e., 6·4 per cent.) and 247 cases of aphasia with right hemiplegia. In respect also of eighty-two autopsies, in two cases (i.e., 2·4 per cent.) the lesion was located in the right hemisphere. Taking the above 676 cases in all noted, of these there were forty-eight in which the right hemisphere appeared to have been affected. This gives a percentage of 7·1 per cent., a number almost identical with 7·3 per cent., the percentage of left-handed children found in elementary schools during the present investigation. This latter percentage (7·3), as will be seen later, is probably too high, when left-handedness is considered from the point of view of a dominant hemisphere. It must be again emphasized that the above number (676) is far too small a one on which to base a percentage in a matter in which there is such a great variability, as has been shown to be the case in left-handedness.

Again, in reference to question of dominance of one hemisphere, Laurence (1869) asks the pertinent question: Why does atheroma (degeneracy of the walls of the arteries) more often attack the vessels of the left hemisphere?

If lesions among adults—apart from tumours, injury, &c.—are found more frequently in the left hemisphere, and in a proportion even approximating to the percentage of the right-handed, then such a fact would seem to be a strong argument in support of the theory of a dominant hemisphere, and of the belief that the dominant side is the one that is more likely to give way under strain in certain diseases of the brain; that in fact the hemisphere that experiences the greatest strain will be the one to break down first.

If there is a dominant hemisphere, and if this dominance is revealed by "handedness," then those with a dominant left hemisphere will be right-handed, and those with a dominant right hemisphere will be left-handed. There will, however, be some who have been driven to the use of the non-dominant side in all or only in some of their activities by various causes, such as are given below.

Various Causes of Changes of Handedness.

(i) *Very simple causes and requiring no explanation.*—(*a*) Loss of right arm, hand, &c., even the loss of a right thumb, appears to have been sufficient to make a child completely left-handed, e.g., a child without right thumb gave the following results, when tested: rubs, throws und writes with left hand, and of course can only use her left hand in cutting with the scissors. Again, a head teacher stated that she is very left-handed, but writes with her right hand; and when tested she gave every evidence of left-handedness. Subsequently she was told by her mother that she was not originally left-handed, but that at 3 years of age she had very seriously injured her right thumb-nail, an injury which prevented her using her right hand for nearly three years. (*b*) Broken right arm: girl, age about 7 years, broke her arm a year ago, attended three months with her arm in a sling. Tested: could cut with left and right, and could write equally well with either hand; in everything else was right-handed. (*c*) Injured right hand: girl, Standard I: writes with left hand, as she had once injured her right hand.

(ii) *Injuries to the nervous or muscular systems.*—Various forms of hemiplegias; in some cases the affected hand cannot be used at all, in others to a limited extent, and in still others the effect is apparently only transitory, and perhaps often unnoticed. All degrees seem to be found in mental and especially in physical defective schools. It would seem that in some cases the affected hand has continued to be used in writing throughout, but that the unaffected hand has been resorted to in many other activities. A very interesting case was met with in one of the mental defective schools, the history of which is given as fully as it could be determined. Like most of the cases met in these schools it is very difficult to obtain accurate information, especially from parents, with reference to dates.

H. H., girl, born April 13, 1906 (even this date was uncertain; it was given at one school as April 13, 1905, and might have been April 13, 1907). Walked at 1 year 10 months, talked at 1½ years; entered an infant school in 1910 about 4 years of age. The head teacher remembered the girl as being normal and bright, and rather "chubby," and not left-handed. From there she went to the seaside, and then reappeared at the girls' school (senior department of the infants' school) on September 22, 1914, i.e., at 8½ years of age, and stayed until October 1, 1914. The head teacher remembered her as not being at all mentally defective, but troublesome and a bad influence on the younger children; and for this reason she was placed among older girls, Standard V(a); she was

in this school only eight days. She next entered another girls' school in the neighbourhood on November 9, 1914, and remained there until November, 1915. She was placed in Standard I. The attendance registers showed that she had made very regular attendances until May 21, 1915. After that date no attendances are recorded until September 21, 1915, and after that the attendances were very irregular until November, 1915. On May 21, 1915, she was apparently 9 years old.

Her mother states that the girl fell from a chair on her head, when she was 8 years old (9 years?) and was insensible from 6 p.m. to 10 p.m.; that this fall produced concussion of the brain; that "there was a bruise on the left temple," and that "the left leg has since had a lot of veins outstanding"; that "she was silly for about four months suffering from loss of memory." It would, therefore, seem probable that the accident occurred on May 21, 1915, as everything points to this date except the assumed age. The head teacher remembered her as being not very bright (as she remained in Standard I for a year), and she thought there had been some accident. The teachers did not think she was left-handed. In December, 1915, i.e., at 9 years and 8 months, she was examined by the medical officer and sent to the mental defective school on January 11, 1916.

At the original medical examination the doctor reports: "Father and grandfather suffer from rheumatism. Child, giddy and hysterical; fits not epileptic (major); an accident nine months ago: concussion of brain by fall, unconscious four hours. Reading, only little words; writing, scarcely legible; drawing, very little." The head teacher of the mental defective school reports, that the girl often makes grimaces and complains of headaches, and her hands are unsteady, and that the mother now states that there is no family history of fits, and that the girl "uses both her hands; she used to use the left hand more," but that the mother does not remember when she first noticed the use of the left hand. Probably if the child had been born left-handed the mother would have remembered the fact. Everything seems to point to the fact that the girl was, until the accident, right-handed. The real evidence of this is the fact that she could hardly write legibly, when she was examined by the doctor at 9½ years of age; such a fact would undoubtedly have been noticed at her former schools. When tested in December, 1919, the following results were recorded: Aged 13 years 8 months; rubs left, throws left, cuts left and right, picks up left, winds left; dynam., left = 38, right = 44; writes right but wants to write left.

She wrote her name mirror fashion with her left hand. Unfortunately she was of course never tested in these things before the accident, but it is extremely unlikely that she was then either left-handed, or wrote mirror fashion (as only 4 or 5 in 1,000 do so). She now writes very well with her right hand, and it will be interesting to discover whether she changes in any of the tests as she grows older. The average grip for normal girls is as follows: for 14 years of age, right 24·79; left 22·92.[1] Her right and left hand grips are therefore far above normal.

[1] Smedley's investigations [28].

S. S. writes with the right hand, but "used to wish to write with the left, owing to paralysis of right hand; the paralysis has much improved." When tested, he rubbed, threw, and picked up with the left; he cut easily with his left, but not very well with his right hand. This, therefore, is the case of a boy who was slightly paralysed, but not so badly as to prevent him writing with his right hand.

A. H. G., a boy, aged 6 years. Had a very serious accident when 9 months old from burning, and was not out of danger for over three months; was noticed by mother and nurse to be very left-handed before and after the accident. An intelligent child: at $4\frac{1}{2}$ years of age began to stammer badly with twitching of eyes; both continued until $5\frac{1}{4}$, when the stammer gradually got less and finally disappeared. At 6 years of age he gave hardly any evidences of left-handedness, except that of holding a glass in his left hand while drinking: he always held a bat in his left hand when knocking about a ball. At 7 years old he appeared to be thoroughly right-handed except in one or two small things. Instruments were used at his birth. It is suggested that some cause affected temporarily the hand centre, &c., and that the passing away of this allowed him to revert to his natural handedness.[1]

One or two further references in connection with this question of dominant hemisphere may be of interest.

James Kerr, 1920 [16], writes: "The right hand has generally a greater capacity for fine adjustments and co-ordinations than the left, which last is then accessory. There is at present no worthy explanation of why the right hand should be so specially used, except that it is driven directly from the left side of the brain, and that in the majority of all races that side gives evidence of a higher state of functional evolution than the other." "The interpretation of sights and sounds into ideas and the intellectual functions which control the voluntary machinery of the organism are commonly bound up with functioning of a highly developed left cerebral hemisphere, so that in normal individuals the left hand, although its motor centres are on the right side, is still driven indirectly through these right-sided cortical centres by the higher control of the left side." And again: "The specialized aptitude or capacity associated with psychical phenomena of speech and reasoning which is so marked in the left brain is best described as dextrality. In a small proportion of individuals the reverse happens: instead of the usual high functional development of the psychic qualities in the left brain it is the right side which shows this property; a consequence appears that the nearest motor centres, those of the

[1] "In these cases of congenital hemiplegia and decided left-handedness (which I believe is not infrequently the result of injury to the left cortex). . . ."—G. Vivian Poore [1].

left hand, become the most specially used and the right remains accessory."

Josefa Ioteyko (1917) [10] asserts that it has been proved that the asymmetry extends not only to the centre of projection, but to centres of language, recognition of objects and signs, purposive activity (the loss of which results in ataxia), and that the localization of these centres is in the left hemisphere for right-handed people.

Further it appears to be true that there is an increase in the percentage of left-handed, beginning with normal children in elementary schools (7 per cent.), increasing in the case of feeble-minded to 18 per cent. and rising to 16 per cent. to 30 per cent. in the case of idiots and epileptics.[1]

In connection with the above statements some very curious facts were noted during the present inquiry, facts which at the time appeared to be very contradictory. Very frequently the teachers in ordinary schools asserted that the children found to be left-handed were the most intelligent and the best at school work; in fact some were stated to be the best in the school. Equally frequently the teachers in the mental defective schools described the left-handed to be the dullest, and of the lowest grade. Ballard, who has special knowledge of left-handed children, states in 1916 that left-handed children compare favourably with right handed in intelligence and school attainments, but he adds that left to right "transfers" (i.e., left-handed children made to write with the right hand) are inferior, and have a tendency to stammer.

One very curious remark was made by the head teacher of one of these special schools, and a special note was made of it at the time, as it appeared to be opposed to what was then thought to be likely, namely, that the change of left-handedness to right-handedness was accompanied by harmful results. The head teacher stated that she had frequently noticed a great improvement in a child's intelligence and school work associated with a natural change of left to right-handedness. There is a very high percentage of left-handed in this school, and no efforts are made to bring about a change. A similar change has been noticed in other schools, an example of which is given below[2]:—

E. Y. (aged 8 years 2 months) throws left, cuts left and right, picks up left, winds left. Copied her name mirror fashion with

[1] Mayet in 1902.

[2] Ireland, W. W. (medical superintendent of Scotland National Institution for Imbecile Children, Larbert), notices a similar change of "handedness" among imbeciles [12].

left, as cannot write it spontaneously. Doctor reports: "Talk four years; walk three years; left-handed at age 7 to 8 years." Head teacher reports: "She is changing from left to right hand in writing without any suggestion from the teacher, and she has begun to improve generally."

There seems therefore to be good reason to believe that there are certainly two distinct types of left-handedness:—

(1) Those who are naturally left-handed, i.e., those who have a dominant right hemisphere.

(2) Those who are naturally right-handed, but who have been driven to the use of left hand in some of their activities owing to some defect of the nervous or muscular systems.

In the case of certain children in the mental defective schools, probably something more than the hand centre or its nerve fibres, &c., has been involved. It also seems probable that the percentage of naturally left-handed in mental defective schools may be no higher than that in ordinary schools, the increased percentage being due to some cause that has brought about the change, before birth, at birth, or at some subsequent date.

These conclusions, as will be remembered, had their origin in the discovery that mirror writing was very prevalent among left-handed children in mental defective schools. A further discussion on mirror writing may therefore be of value. The following are some of the conclusions of other investigators on the subject:—

"In 200 apparently healthy people, only the neuropathic wrote mirror fashion; in 200 sick subjects only those suffering from nervous disorders wrote mirror fashion" [15]. Soltman found (number tested 77) 35 per cent. were mirror writers among deaf-mutes.

Kerr [16] states: "Mirror writing also occurs pathologically with the right hand, being common among hemiplegics and others with brain disease, although even here unusual with better class or well educated individuals. It is to be observed frequently in the developing child. Children becoming deaf soon after birth are said to mirror generally with the left hand, but if the deafness supervenes later the mirror writing does not occur."

McHattie quotes that mirror writing is frequently observed in nervous diseases, e.g., hemiplegia, hysteria, and locomotor ataxy. Among his own observations he gives the case of a girl whose right arm had been partially disabled by infantile paralysis, and who could not in consequence write with her right hand [20].

J. K. Fuller [7] (1916) gives four cases of subjects under hypnotism, three of whom wrote mirror fashion with left hand; one of these is definitely stated to have no inclination to left-handedness.

C. H. Judd also states that "Certain persons when hypnotized produce mirror writing with the right hand" [21].

F. T. Allen (1896) [2] says that mirror writing was discovered when nervous disease rendered normal writing difficult or impossible, and he concludes that it is often a symptom of nervous disease.

F. B. Sherlock [24] writes: "One finds rather widely prevalent the notion that a characteristic of idiocy is that whereas the normal person writes from left to right and with the right hand, the idiot writes from right to left with the left hand . . . the script is meaningless until it is held before a mirror.

"Good examples of this kind of writing are rare, at any rate in this country (England); for idiots do not write at all, or they produce a scrawl, which demands the use of a good deal of ingenuity, in addition to a mirror, if anything is to be made of it.

"Ambidexterity, as we shall see, is commoner in idiots than in normal persons, and the particular accomplishment which we are considering seems to be a special case of it."

Although the following quotation (Kerr [16]) does not specify mirror writing, it seems to indicate that such peculiarities may be expected in such a class.

"Whilst in the last class (i.e., defective functioning of both hands) are individuals whose dextrality has not been properly developed, and who are in this sense mentally defective, and on further examination may be expected to present not merely gaucherie, but speech defects, and the various degenerative stigmata in relatively large proportions."

Various explanations have been given as to the cause of mirror writing, but none of them are altogether satisfactory, and they do not account for many of the known facts.

There is no doubt a tendency for the left hand to move in a way similar to movements made by the right hand, e.g., in the simple case of drawing two circles at the same time—one with the right, the other with the left hand, as is illustrated below:—

Left. Right

Some experiments were made in the ordinary elementary schools on the effect on the left hand of right-hand practice. Young children 2 to 3 years of age when they begin to use pencil or chalk usually draw a series of circles, thus :—

The direction with the right hand is as indicated by the arrows, i.e. clockwise. If the pencil is held in the left hand the direction is exactly the opposite, i.e., anti-clockwise. The first fact is well known in infant schools, as teachers have some difficulty in persuading children to write an "a" in the usual way, since nearly all begin by writing it as follows :—

instead of and as is usual among older children.

The following results were obtained by asking each child to copy a circle, drawn on a piece of paper or millboard placed before them, first with the right and then with the left hand. Care was taken that the children should not see what had been done by the others, and should not know what they were to draw until they were asked to do it.

Circle drawing with the left and right hand. Note, "N" indicates the natural way, i.e., clockwise with the right, anti-clockwise with left. "A" indicates the artificial way, i.e., anti-clockwise with the right, clockwise with left.

The results obtained with the right hand will be given first.

CIRCLE DRAWING WITH THE RIGHT HAND.

		Percentage of drawing in artificial way
Infant school, average age 4 years 4 months	.. 33 children	.. 27·2 per cent.
" " " 4 to 5 years	.. about 40 "	.. 15·0 "

These had not been taught to write.

Infant school, average age 6 years 5 months	.. 37 children	.. 81·0 per cent.
" " " 7 " 5 "	.. 55 "	.. 92·7 "
Boys' school, Class I, average age 12 years 5 months	40 "	.. 100·0 "

That is to say, these children showed a gradual change from the natural to the artificial way of drawing a circle on paper or millboard.

This change was undoubtedly brought about by the continued practice, in writing, of such letters as a, o, d, g, &c. The drawing of circles on the blackboard gives however different results, no doubt in part because it is an arm movement. In the above experiments, and in those that follow, the results given in the case of the babies (i.e., under 5 years of age) are very variable, and not very trustworthy. It would have been much better to have watched these children, and to have noted from time to time how in their ordinary drawing they formed a circle, as it often seemed a mere chance which way they drew the circle; sometimes due to the position of the hand, at others to that of the millboard. The same kind of thing was even more noticeable with their left-hand drawing.

DRAWING CIRCLES WITH LEFT HAND.

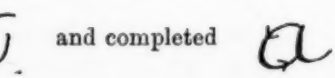
				Percentage who drew circle in artificial way
Infant school, average age	4 years 4 months	..	33 children	.. 36·3 per cent. (not very reliable)
,, ,, ,,	6 ,, 5 ,,	..	37 ,,	.. 21·6 per cent.
,, ,, ,,	7 ,, 5 ,,	..	55 ,,	.. 21·8 ,,
Boys' ,, ,,	12 ,, 5 ,,	..	40 ,,	.. 40·0 ,,

More often than not those who drew in the artificial way with the right still drew in the natural way with the left.

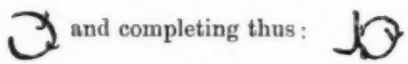
From these insufficient data however it would appear that in some cases the artifical way of drawing with the right had affected the left-hand drawing, as the children (classes ages 6 years 5 months and 7 years 5 months) who drew in the artificial way with the left were those who had also drawn in the artificial way with the right. In these two classes (92 children) only one—a boy—drew in the artificial way with the left, after having drawn the circle in the natural way with his right hand.

The elder boys show a greater change, as the artificial drawing with the left hand has increased to 40 per cent. Whether such a result would be confirmed by further experiments remains to be seen.

There is evidently a tendency, especially when both hands are used at once, for one hand to follow the other mirror fashion. This fact, however, in no way explains mirror writing of children when they begin to write, many examples of which are well known. As a matter of fact an "a" written by the left hand in the ordinary writing is in accordance with the natural tendency of that hand.

Thus and completed 

To write this letter mirror fashion with the left hand would involve the forming of the circle in the artificial way with that hand, thus :—

 and completing thus :

As a matter of fact, a fair number of mirror writers did actually write the letters "a" and "o" mirror fashion with the left, but the circle part was drawn in the natural way, i.e., .

A widely accepted explanation of mirror writing is given below, but it certainly does not explain all the facts ; nor does it explain why so many more so-called left-handed children write this way with their left hand, unless it is suggested that left-handed children are more motor than visual inclined.

"If a man is of the so-called 'visual' type, i.e., if he depends mainly on his *v* series in his writing, the *look* of the letters, &c., and by comparing it with the resulting writing, conforming his movement series to it, then any movements which violate the figure presented by visual memory are unintelligible. Such a man must reproduce, with his left hand, the visual images as produced by the right. That is, he must write from left to right, with both hands, which involves symmetrical movements. This represents the power of the *v* series to bring the movements of both hands in conformity to it. If, on the contrary, his *m* (motor) series has grown independent by practice, and he remembers written words not by the way they look mainly, but by the way it feels to write them—if he is the so-called motor type in his hand writing—then his left-hand writing must produce the series of muscular sensations as his right hand has established. This represents the power of movements established by one hand to carry the other hand also with it in a symmetrical way. His left-hand position must duplicate at each moment his right-hand position, when he comes to try the experiment of writing in the air with both hands. This gives symmetrical movements with the two hands, which means mirror writing with the left hand"[1] [2].

This symmetrical movement of the two hands has been held by Fechner and others to be a strong proof that the discharge of energy into one side of the body tends to stimulate the corresponding members of the other side to similar movements. Lochte [18] and Weber [27]

[1] J. M. Baldwin : "Mental Development in the Child and in the Race" (1895). A somewhat similar explanation was given by Goldscheider in 1892 [9].

suggest that writing is primarily a motor act controlled by the optical image, which is a later development. Consequently if the mind and the eye are centred on the right hand, we should expect the left hand to follow out the movements of the right hand, and therefore write mirror fashion.

E. J. Allen [2] remarks that the sensations accompanying all kinds of writing, whether right-handed or left-handed, are so similar as to suggest that they all start from the same region of the brain, but that there are a series of commutators at a lower level whereby impulses are turned into different channels. He further suggests that this supports the view that the true graphic centre coincides with either motor centre, but is superior to all.

Josefa Ioteyko (1919) [10] concludes from experiments made in her laboratory by Mlle. V. Kipiani, " . . . in the first place, that the movements acquired by the left hemisphere (which directs the movements of the right hand) are transmitted to the right hemisphere, and, secondly, that this transmission is not purely and simply an increase of excitability, but that it comprises all the complicated movements necessitated by the act of writing—in a word, that the characteristics of hand-writing certainly have their origin in some central cerebral cause."

Before considering further the hypothesis as suggested by Baldwin (p. 353) some examples will be given of mirror writing associated with various forms of paralysis, and with other physical defects.

M. S., aged 13 years 10 months, girl: "Mother in an asylum; in good health until 6 years of age, then a fit with paralysis, right hemiplegia. Reading nil; easy numbers, mentally only; can write fairly well with her left hand; no memory; speech slow and drawling (September 13, 1916); a few letters and words (September 6, 8, June 17). Sleepy, dull and exceedingly slow even for a mental defective; cannot spell "cat" (June 17). "Talks well about her own affairs." The doctor in his last report dated December 19, 1919, states that she is "word blind."

In all the tests that could be tried, she was of course thoroughly left-handed; she could cut easily with her left hand; her strength of grip was 30 kg.

At the first visit all the children in her class were asked to write their names with their left hand and then with their right. Her paper when given up had her name well written at the left side; but there was near the right margin a curious scribble, and emerging from it her name written mirror fashion; the writing was rather shaky. It was originally believed to have been written with her right hand. On a subsequent visit she was watched while she wrote; she immediately wrote her name with her left hand, beginning

in the usual place; the pencil was then placed in her right hand, she had difficulty in holding and using it, but tried her utmost. After scribbling with an arm movement, she took the pencil in her left hand and wrote her name mirror fashion, rapidly and in excellent fashion. She was not known at the school to have written mirror fashion before.

L. C., girl, born April 20, 1907: infantile paralysis, very small for her age. Doctor reports paralysis of right leg and arm; writes mirror fashion with left hand; had given up mirror writing in April, 1916 (i.e., 9 years old); in 1917 (i.e., 10 years old) writes mirror fashion sometimes. January 19, 1920, when asked to try to write her name on the blackboard with her right hand, printed it very well, but all mirror fashion.

Mirror Writers in Physical Defective Schools.

M. A., girl, paralysed both legs. Mentally defective; tested: rubs and throws left; cuts left and right; wrote mirror fashion with her left hand.

J. S., aged 13 years 8 months, boy. Infantile paralysis right lower limb. Nervous. Cuts left and right; writes right. Doctor reports: "Leg flail-like though not very wasted." This boy tried twice not to write mirror fashion with left, but finally wrote both names completely mirror fashion.

A. S., boy, aged 11 years 3 months. Rubs and throws left, cuts left only; writes right, but sometimes left; is thought to be verging on feeble-mindedness. Doctor reports: "Right hemiplegia; slight weakness of right arm and leg, not wasting. Used to fall about a good deal."

J. S., boy, aged 14 years 1 month. Apparently right-handed, mirror writing very shaky indeed. Doctor reports, at 7 years 3 months of age: "Spastic paraplegia (partial); spinal paralysis; right ptosis; very intelligent; at 10 years 2 months, paralysis of eye and legs, getting worse; scissors legs." At present time school staff reports: "Not very intelligent."

E. G., boy, left-hand writer. Writes mirror fashion sometimes also 21 for 12, i.e., beginning with 1 and then writing 2 on the left of it; hydrocephalous.

C. R., boy, aged 8 years 3 months. Writes mirror fashion with left hand when tired. Doctor reports at 5 years 11 months: "Spina bifida, lower cervical region; night terrors; at 8 years 2 months, very backward; spina bifida apparently closed."

J. P., boy, aged 15 years 2 months. Throws left but writes right only; dynamometer left = 34, right 26. Doctor reports at age of 6 years 5 months: "(Brother dead, suffered from fits). Spinal caries (lumbar region), can pick up things. At 11 years 5 months pains in right leg. At 7 years 11 months no active disease; much lordosis, apparently habit."

F. B., boy, aged 8 years 4 months; very large head. Doctor reports: "Infantile paralysis at 2 years 11 months; paralysis of both legs; right arm and leg not bad; operation for talipes. December, 1916, marked wasting of leg and thigh muscles. October, 1919, operation for tubercular disease in third metatarsal bone, sinus still discharging. Bright child."

F. S., boy, aged 10 years 11 months. Right-handed in all tests. Dynamometer, left = 33, right = 32. Doctor reports: "Spinal caries, lower dorsal, at 4½ years."

These nine, together with one left-handed girl suffering from mitral stenosis, who had been in a mental defective school for three years, were the only mirror writers among 706 children tested. It will be noticed that three of these ten were merging on mental deficiency, leaving seven among the physical defective children, i.e., 1·1 per cent. It is remarkable that in six cases there is some spinal lesion, or paralysis of the lower limbs; the seventh is that of a hydrocephalous child.

As reference will be made later to mirror writing by children, when they first began to write, the following cases are given:—

EXAMPLES OF CHILDREN WHOSE FIRST ATTEMPTS AT WRITING WERE WITH THE LEFT HAND AND WERE REPORTED TO HAVE BEEN MIRROR FASHION.

	Age	Sex	Rub	Throw	Cut	Writes	Doctor's report
	Yrs. mths.						
W. S...	..	Boy	R.	L.	O.	L.	
H. S. ..	10 6	Boy	L.	L.	L.	L. and R.	"Bossed forehead; stunted; speech indistinct"
H. W.	8 8	Boy	L.	L.	L.R.	L.	"Speech inarticulate; decided epicanthus; mental age IV. (Binet)"
C. B. ..	10 8	Girl	L.	L.	L.	L.	"Defect of articulation; low bulging forehead"

Similar cases reported by other investigators.

A. L. Beeley [6], 1918, reports and gives details of three boys and two girls, all of whom wrote mirror fashion when they first attempted writing. They were all extremely left-handed and had, with one exception, left-handed near relatives. One, a boy, had not overcome the habit at the age of 7 years 11 months, as "he still frequently lapses into mirror writing."

If there is any truth in the suggestion that those who write mirror fashion with their left hand in mental defective schools are really right-handed (with a dominant left hemisphere), but have some defect in this hemisphere or in the nerve fibres connecting it with the opposite side of the body, a defect which has temporarily or permanently affected the children, then the few who, although they wrote mirror fashion with their left hand, yet in nearly every test reacted right-handedly, would probably display some left-handed activities in some of

their habits—activities, however, that had been insufficient to classify them among the left-handed.

The actual number of those children was five boys and eight girls.

It may therefore be asked whether there is any evidence that these children had at any time used the left hand as the dominant hand in any of their activities, that is, whether they had passed through a left-handed stage and afterwards reverted to the right hand.

The following cases are collected from notes made at the schools; in some instances, however, the data are rather meagre, as at first little was attempted beyond the determination of the percentage of left-handed children in these schools.

Mirror writers who appeared to be right-handed:—

(1) L. C., girl: very good mirror writer: rubbed left or right, kicked persistently with the left foot, but in everything else reacted right-handedly.

(2) B. C., girl: a very good mirror writer; reacted right-handedly to every test, except (1) dynamometer, left = 36, right = 34; (2) a special note was made of her holding her left arm stiffly when catching.

(3) R. R., girl: (1) rubbed with left but afterwards with right; (2) held her left arm down when catching; (3) dynamometer, left = 38, right = 32.

(4) W. S., boy: mirror writing poor; reacted right-handedly in everything except the dynamometer, left = 39, right = 25.

(5) G. S., boy: hydrocephalous with very little power in his legs; reacted right-handedly in everything except "winding," and dynamometer, left = 15, right = 12.

(6) E. T., boy: reacted right-handedly in everything, but held his left arm down characteristically while catching.

(7) H. L., girl: right-handed in everything except grip test: dynamometer, left = 30, right = 19.

(8 and 9) G. C., boy; F. C., girl: no left-handed indications, but wrote mirror fashion with left hand very well.

(10) M. J., girl: no indications, but she copied from a book a whole page correctly and rapidly with her left hand.

Of course it may be argued that every child may do something left-handedly, provided a sufficient number of tests are tried. The results of these tests are given, but too much weight must not therefore be attached to any conclusions that may be drawn from them. There were certainly a few cases where the children who wrote mirror fashion with the left hand gave no indications of left-handedness. It seems not impossible that some at least of the above children may have acquired left-handed habits at one time of their life, but that only one or two of these habits may have persisted. Why some habits may

persist, and others be lost, it is difficult to say, but one example is very illuminating:—

L. F., a girl: mirror writer, reacted right-handedly, but only cuts easily with her left hand with the special scissors. She always sews and knits left-handedly. It seems evident that she must have been left-handed, when she learnt to knit, as nearly all teachers try to make the girls right-handed in knitting and sewing. Having once learnt to knit left-handedly, it can be easily understood why she continued to do so, although she may have changed into right-handedness in everything else. She suffers from epileptic fits.

Before drawing any further conclusions from the facts as given, it is very necessary to examine more carefully the theory as stated by Baldwin (p. 353) to see whether the facts in reference to mirror writing may not be sufficiently explained by such a comparatively simple hypothesis.

The hypothesis is in short that in the case of those who are of the so-called motor type in hand-writing the left hand will reproduce a series of muscular sensations as has been established by the right hand, that is, that they will remember written words not by the way they look mainly, but by the way it feels to write them.

Undoubtedly in drawing a line or a circle the tendency while using the right hand is to draw the line from left to right, and the circle clockwise. A similar feeling will be experienced by the left hand in drawing a line from right to left, and a circle anti-clockwise. This tendency would undoubtedly explain many cases of mirror writing, but it certainly does not seem to explain:—

(1) Why so many mirror writers in mental defective schools are very left-handed in many of their activities.

(2) Why some children write mirror fashion when they first begin to write, as no muscular sensations can have been established in such cases. Of course the same argument holds in the examples of mirror-writing with the right hand.

(3) Why so many mirror writers, although they now write with the right hand, at one time wrote with the left. It would seem probable that any practice in writing with the left hand would have tended to correct an inclination to write mirror fashion with same hand at a later period, and that these children would therefore be less liable to such kind of writing than the right-handed child, who writes with the left hand for the first time.

(4) Why a girl with the right upper limb paralysed at 6 years of age, who had written with her left hand in the ordinary way for nearly

eight years, should suddenly write mirror fashion with the same hand, after making an effort with her right hand.

Also other cases of mirror writing by left-hand writers who had suffered from right hemiplegia from an early age.

(5) Why "certain persons when hypnotized produce mirror writing with the right hand." Should this statement be true, only one explanation seems possible, if it is to be in accordance with the above hypothesis, namely, that these "subjects" were really left-hand writers.

There also seems no reason to believe that left-handed children (even among the feeble-minded) should be more frequently of the "motor" than the so-called "visual" type. There is however this to be said, that a child with a fairly skilful left hand may be able to write with this hand without paying so much attention to what is actually being written, and for this reason might be inclined to trust to a feeling of the movements of the hand rather than to the actual forms of the letters and words written. On the other hand it has been pointed out that some children have actually attempted to correct their movements, thus clearly indicating that they had noticed that there was something wrong. These attempts, however, were not always successful. One or two examples of such attempts are given below.

(1) A boy wrote the first letter of his name mirror fashion; he then started again and wrote the first two letters of his name in the same way. Even after these two unsuccessful attempts he finished by writing both his Christian and surname completely mirror fashion.

(2) Two or three children at least wrote their names or parts of their names mirror fashion, and then turned over the paper and had another try, but with no better success. It would seem that these children had noticed what they had done, but could not make their left hand do what they wished or expected.

We might, however, supplement the hypothesis under discussion by supposing that there is no real necessity for assuming an established series of muscular sensations, that are then reproduced by the left hand in a "reflected" manner (i.e., mirror fashion). For we can go this far and suggest that quite apart from the establishment of such a muscular feeling there is a "natural" direction of writing with the left hand and that it is from right to left, and that this natural direction may quite well involve a tendency to form letters and even words in a manner the reverse of the natural way with the right; that is to say, that even before letters and words have been copied by the right hand there will be an inclination for the left hand to write mirror fashion

unless corrected by visual sensations. Suppose therefore mirror writing is the more natural method of writing with the left hand, but the tendency is corrected by the look of the letters and words, then the first writing, before the correlation of the hand and eye has been perfected, may well be mirror fashion, as has been found in some cases. But such an explanation is negatived by mirror writing with the right hand by beginners.

Again, the original theory as stated by Baldwin might explain in a simple manner why the feeble-minded were more prone than normal children to write mirror fashion with the left hand, after they had learned to write with the right. It would seem quite justifiable to suppose that mirror writing by the hand not habitually used in writing is the automatic reproduction by that hand of the ordinary writing, and that it is due to some mental defect, probably a defect of the higher centres (involving voluntary action), the disarrangement of which has let loose the more automatic "activity of the lower centres, or the nervous arrangements which have escaped injury," and has thus allowed the unpractised hand to follow the more automatic series of movements.[1] In the case of hypnotized "subjects" such an explanation would equally apply, provided the mirror writing was done by the hand not habitually used in writing, but it would of course be negatived by mirror writing with the right hand by right-handed "subjects." There is further evidence in support of this explanation in the case of children who lapse into mirror writing when inattentive. Beeley [6] gives the following examples:—

(1) Boy aged 8 years 3 months; bright, lapses into mirror writing when inattentive, knows the difference, very good memory, left-handed writer, left-handed family.

(2) Boy, aged 7 years 11 months: not yet overcome tendency to mirror writing; when his attention shifts from the "executive factor" to the "thought element" lapses to mirror writing. Stated to have written mirror fashion from the beginning, at 4½ years of age, and not to have recognized that it was wrong.

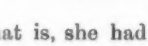
Other experiments were made with letters cut out of stiff paper and placed on the table the reverse side upwards, to see whether mirror

[1] If this is a true explanation one would expect mirror writing to be frequently found in the numerous cases of lesions which have affected the higher centres, and have been associated with aphasia and right hemiplegia. But this appears to be very seldom the case among adults; in fact Moutier gives only two examples of mirror writing among all the cases in his book [22] [Nos. 361 and 172].

writers would arrange them from right to left or attempt to arrange them in the correct direction, i.e., from left to right.

L. J., girl, aged 11 years 10 months: left-handed in all the tests, but writes with the right hand, and wrote mirror fashion with the left at a previous visit. When given the mirrored letters, and asked to form with them the words "cat" and "dog," using her left hand, she arranged them without any hesitation mirror fashion, i.e., from right to left. The same letters were then rapidly and without her knowledge turned the right way up; she now arranged them with the same hand in the correct position. Exactly the same result was obtained with the right hand. A 4 and 5 were then given her, and she was asked to make 45 with them, using her left hand. She arranged them thus: , but seemed dissatisfied with the result. After looking at them for a short time, she took the 5 and placed it on the right side of the 4, thus: .

The following case seems to indicate that the mirrored letters are sometimes at all events a reproduction of an optical memory image, and not a mechanical reversal of what has just been seen.

E. Y., girl, aged 8 years 1 month: reported to be changing spontaneously from left to right in writing. Left handed in all the tests. As she could not write her name spontaneously it was printed, and she was asked to copy it with her left hand. The name was printed thus: "Esther." She copied it as follows:  —that is, she had changed the small "t" and "e" into capitals "T" and "E."

The curious case of children printing with their right, and writing mirror fashion in a "running" hand with the left, and also those who write mirror fashion slowly and obviously looking at each letter as it is being written, seems to indicate that it is a reproduction of an optical image.

Kerr states: "Similarly infants, tested with copying English and Russian words, only made mistakes with letters common to both alphabets—that is, those with whose forms they had some slight acquaintance—but copied correctly the complicated letters peculiar to Russian, whose form they had never seen before" [16].

From such facts it would seem that something had affected the nerve fibres connecting the hypothetical visual memory of words centre with other parts of the brain; this centre, if there is such a one, is generally believed to be situated in the dominant hemisphere. If this

should be the case, the association of left-handedness and mirror writing might be explained by some lesion that has affected the dominant side of the brain, or by a lack of development of this side—resulting in some form of mental deficiency, in a change of right to left-handedness, and in mirror writing.

Chapter VI.—Defective Speech and Left-handedness.

Ballard and others [5] [14] have shown that stammering is more prevalent among left-handed children, who write with the right hand, than among " pure " left or right-handed children. Also Lewis [17] has reported that epileptic children—originally right-handed—first hesitated in speech, and then developed a decided stammer, after being trained to write with the left hand in the ordinary way, i.e., in the direction left to right. These same children had previously shown no indication of hesitating in speech, although they had been practising writing with the left hand for two or three months, but the writing had been mirror fashion and from right to left in direction. That is, a change in direction of the writing with the left hand did not seem to affect the speech, but when the direction was unchanged then the speech appeared to be affected. This is also what appears to be the case with some left-hand writers who have changed to the right hand, but of course no experiments have been made with left-hand writers to see whether mirror writing with the right hand would have the same or a different result.

During the present investigation many instances of the same kind were noticed among normal children, but it appeared that among mental defectives there were just as many stammerers among left-handed writers as among left-handed children who wrote with the right hand. In addition to this, defective articulation and other speech defects seemed to be prevalent among mirror writers. No special note was at first made of such defects, as it did not seem probable that the association of mirror writing with defects of the speech was anything more than a coincidence. Later, however, much greater importance was attached to these facts, especially when it seemed likely that many of the children with left-handed activities might be right-handed children (i.e., with a dominant left hemisphere), children who had been driven to the use of the left hand by some defect of the left hemisphere, or the nerve fibres connecting this hemisphere with the right side of the body. As (p. 343) paralysis of the right side

(right hemiplegia) is frequently associated with aphasia, and it is therefore possible that with these mental defectives the same defect may have affected not only the hand but also the speech of these children. The following cases are of interest in connection with this subject.

(1) M. G., girl, born March, 1911. Doctor reports: "Meningitis at 2 years; speech defect the most prominent feature; left-handed. February, 1918: ditto, and poor at manual work, October, 1919." She was tested April, 1920: rubs right, throws right, cuts left and right, writes right. The head teacher reports: "She uses her left hand at times in some things."

(2) E. H., girl, born March, 1910. Doctor reports: "Mother says: 'lost her speech for eleven days, and was like an idiot for a week.'"

Tested April, 1920: Throws left, cuts left, picks up left, writes right and left; knits left; dyn., left 13, right 15.

(3) J. P., boy, born February, 1907. Doctor reports: "Premature birth 7 months; drags right leg; ? hemiplegia; talipes; right hand less powerful than left; slight defect of speech; left handed January, 1916; stammers January, 1918; slightly deaf, otorrhœa (right ear); slight paresis of legs."

Tested April, 1920: He still stammers. Throws left, cuts left and right, picks up left, winds left, writes left. This is interesting, as it seems to be a case of slight right hemiplegia with a slight speech defect, which developed into a stammer.

SPEECH DEFECTS AMONG MENTAL DEFECTIVE CHILDREN.

	Left-handed		Right-handed	Total
	Write with Left hand	Write with Right hand		
Stammer or stutter	19	20	44	83
Defective articulation..	14	1	18	33
Defective speech, including some cases of defective articulation	39	27	40	106
Lisping associated with other speech defects	6	1	7	14
Great hesitation in speech	0	2	1	3
	78	51	110	239
Percentage ..	32·6 %	21·3 %	46·0 %	99·9 %
	53·9 %			

The above statistics have been made out in connection with children with very defective speech; in every case they have been tested in "handedness." Now, as there are about 81·8 per cent. right-handed among mental defectives, and 18·2 per cent. with many left-handed activities, there are, therefore, four and a half times as many right-handed as left-handed, and if very defective speech is not associated with left-handedness, then there should be among these children

with very defective speech four and a half times as many right-handed as left-handed. The results of an investigation on this subject are given above. The numbers are not large, and therefore the result can only be treated as provisional. Cases in which the causes of the defect seem to be clear have been omitted, e.g., split palate, bad adenoids, &c. The number of cases was 239; all the children stammered or had stammered, or were stated to be bad cases of defective articulation or of defective speech.

From the above it will be seen that taking the various speech defects (239), more than half are left-handed, whereas one would expect about 18 per cent. or so to be left-handed unless there was some connection between left-handedness and speech defects. The number of stammerers among the left-handed and among left-handed children who write with the right hand are approximately equal, i.e., nineteen and twenty respectively. These statistics deal exclusively with mental defective children, and it is probable that the same result would not be obtained with normal children. If this is the case, and it seems likely from the results of previous investigators, then it becomes a matter of great importance, as it would seem to indicate that there is something quite distinct in the left-handedness of children under investigation, and that this left-handedness is frequently associated with speech defects.

An interesting case not included in the above is that of a child with defective speech :—

A. W., girl, aged 15 years 8 months: was paralysed (left arm and side) at 2½ years of age. She does everything right-handedly, and cannot even hold a pencil in her left hand. It seemed likely that she was originally left-handed, and that the paralysis had affected her dominant (right) hemisphere, as she is in a mental defective school and her speech is defective. Her mother was therefore questioned, and she stated that "the girl was left-handed until she had the paralytic stroke."

Summary and Conclusions.

Left-handedness.

(1) The percentage of left-handed children (i.e., with marked left-handed activities) is much higher in mental defective schools than in ordinary elementary schools :—

Percentage in ordinary schools	7·3
Percentage in mental defective schools	18·2

Note.—(i) About 7·2 per cent. in mental defective schools write habitually with the left hand; (ii) the percentage of left-handed girls (mental defective schools) is about 25 per cent higher than that of the boys.

(2) Left-handedness in mental defective schools is more frequently associated with defects of the speech than is right-handedness (p. 364).

(3) In the case of twins, when one is left-handed and the other right-handed, the left-handed twin is frequently backward, less developed, highly nervous, or even in a mental defective school, whereas the right-handed twin is normal and in an ordinary elementary school. Among twins (a boy and a girl) there is a very high percentage (nearly one-third) where one is left-handed and the other right-handed.

(4) Among normal children the left-handed are frequently the most efficient and capable; among the mental defectives it is exactly the reverse, left-handedness being often associated with marked deficiency. Spontaneous change of left-handedness to right-handedness in writing among mental defectives is often found to be associated with progress in school work and in intelligence.

Mirror Writing.

(5) The percentage of mirror writers is much higher in mental defective schools than in physical defective schools and in ordinary elementary schools.

	Elementary schools	Physical defective schools	Mental defective schools
Percentage of mirror writers ..	0·48 ..	1·1 ..	8·0

(6) Percentage of mirror writers among left-handed and among right-handed children in mental defective schools:—

	Left-handed	Right-handed
Boys	18 per cent. ..	1·6 per cent.
Girls	40 ,, ..	2·8 ,,
Boys and girls ..	30 ,, ..	2·2 ,,

(7) Percentage of mirror writers among left-handed children who write with the right hand:—

Boys	32 per cent.
Girls	62 ,,

The great majority of mirror writers are children who are reported to have written with the right and also with the left hand, but this is not invariably the case, as many mirror writers, although left-handed in many things, are said to have never written with the left hand; other mirror writers suffering from right-hemiplegia from an early age have never written with the right hand.

(8) Children who are reported to write on some days with the left and on other days with the right hand can frequently be made to write

mirror fashion by merely asking them to begin at the right edge of the paper. Some of these children write in the same way with the right hand; others cannot be induced to write mirror fashion with the right hand. In many cases these children have never been known to write mirror fashion before. Children reported to have written mirror fashion when young can often be induced to write mirror fashion under similar conditions.

(9) Many left-handed children are reported to have written mirror fashion with the left hand when they first began to write and to have persisted for some time. A few right-handed children also wrote mirror-fashion with the right hand when they first began to write.

(10) In no case has a left-handed writer been reported to have written mirror fashion on changing from left to right hand writing. These same children when asked to write with the left hand frequently do so mirror fashion.

(11) In some instances all the letters are written mirror fashion with the exception of one or two letters, and these are persistently written correctly, and with both hands; in the other cases the correct letter (with left hand) is written mirror fashion with the right.

(12) Of the 109 cases of mirror writing, eight (i.e., 7·8 per cent.) wrote mirror fashion spontaneously with the right hand and correctly with the left.

(13) Mirror writing seems in some cases to be due either to (*a*) a motor memory image, or to (*b*) an optical memory image (p. 361).

Theoretical Conclusions.

There are undoubtedly some peculiar and uncommon characteristics (uncommon even among mental defectives) among some of the left-handed children in mental defective schools, especially among those who write with the right hand. The fact that very many of the mirror writers are left-handed is merely a statement of fact and no explanation. There seems no adequate reason for believing that naturally left-handed children (i.e., with a dominant right hemisphere) should be more prone to mirror writing than the naturally right-handed (i.e., with a dominant left hemisphere), nor is there any reason for supposing that naturally left-handed children should be more inclined to suffer from speech defects than the right-handed. In addition to these facts there are undoubtedly a much larger number of left-handed among mentally defective than among normal children, and many of these are of a very low-grade type.

There seems at present to be only one explanation possible, and this explanation would clear up many, if not all, of the observed peculiarities and apparently contradictory facts. It of course does not go to the root of the matter, and much still requires elucidation.

The hypothesis suggested is that something has occurred which has interfered with the proper functioning of the dominant hemisphere—in the majority of cases described it is, of course, the left hemisphere. Such a supposition would explain :—

(1) Why there are so many left-handed in mental defective schools. The left hemisphere being affected has interfered with the proper functioning of the right hand, perhaps in only a slight degree, as many among the older children change spontaneously from left to the right hand in writing. The same cause has probably affected the functioning of many of the higher intellectual centres, supposed to be situated in the same hemisphere, involving such peculiarities as mirror writing and defective speech.

(2) It would also explain why, in the case of left and right-hand twins, the left-handed twin and not the right-handed is found in these special schools.

Whether the hypothesis is true or only partly true, or whether it is untrue, is not of great moment for the present; it has undoubtedly indicated new lines of investigation, and has been fruitful in suggesting fresh experiments and observations.

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TONUS AND THE REFLEXES.

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[*Delivered before the University of London on January* 17, 1921.]

THE Anglo-Batavian Society put forward the project recently for a series of lectures to be delivered in England by Dutch and in Holland by English medical men. Through the whole-hearted co-operation of the Royal Society of Medicine and the University of London, as well as of the Royal Academy of Amsterdam, this project has become reality. I have been invited to inaugurate this series from the Dutch side. The undoubted temerity of accepting this invitation is only to be explained by my knowledge of the generous judgment and courteous forbearance with which my fellow-workers in the field of science are received in your midst. Yet I fear that I shall have to crave your kindness and indulgence.

The subject of my lecture is one which in Holland is engaging many workers, and on which I have also expended considerable thought and time as well. I mean the question of tonus and reflexes. In my work on this subject I made an extensive use of Einthoven's ingenious invention, the string-galvanometer. I hope to show you a very small part of this work and to submit to your consideration some remarks on the result and conclusions to be drawn from it.

The investigation of the electric response of contracting striped muscle by means of the string-galvanometer has led us to classify the muscle contractions into three different groups. A representative of the first group may be found in the simple muscle twitch, such as is elicited by stimulating a motor nerve of the muscle itself with one condenser discharge or an isolated break-shock from the secondary of an induction coil. The resulting muscle twitch is characterized by its short duration as well as by its being preceded by a double-phase action current. During the contraction itself the muscle is electrically inert. An example of the second group is the voluntary muscle contraction, which is characterized by a current of action in the form of a rather irregular alternating current with a frequency of about 50 periods per second. The electric responses of the first and of the second kind can easily be

recorded in our patients. The last group comprises all kinds of muscular actions in which no electric current of action can be detected.

To these three groups we might possibly add a fourth, comprising contractions caused by special forms of electric stimulation, in which we are able to record a few abnormal forms of electrical response. As these contractions are always artificial and never occur physiologically, and as they have no direct bearing upon our subject, we need not take them into further account.

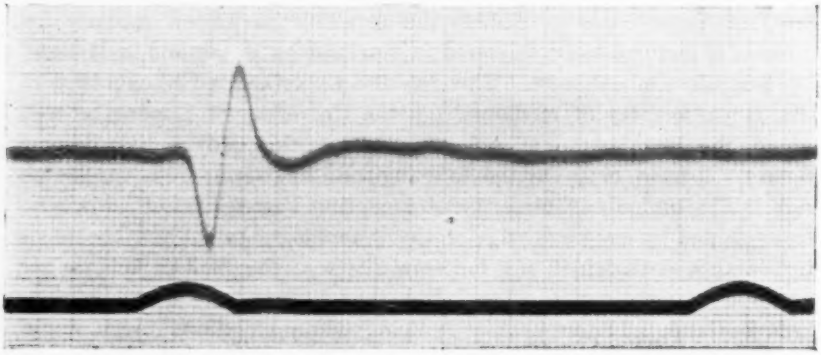

FIG. 1.—Knee reflex. Electromyogram. 400 mm. per second.

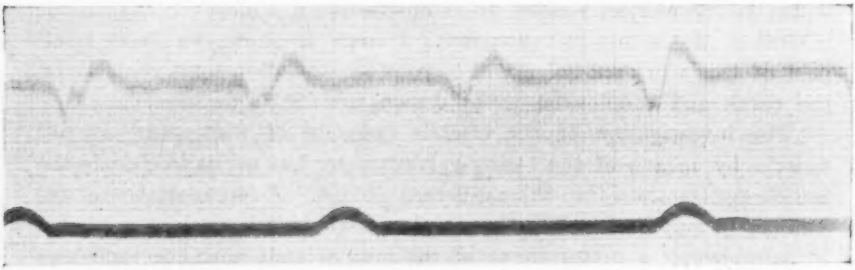

FIG. 2.—Knee clonus in myelitis. 250 mm. per second.

In human physiology and pathology muscle contractions of the first kind, in the form of simple muscle twitches, are to be found, of course, after electric stimulation, but also, as I found in 1907, in all deep reflexes, tendon reflexes as well as periosteal reflexes. In cases of muscle-clonus in lesions of the lateral tracts, I found a regular series of simple twitches, each starting after a complete biphasic action current. Between these

the galvanometer-string practically does not move at all. I have not been able to find a single other instance of the occurrence of simple muscle twitches under physiological or pathological conditions.

The second kind of muscle contraction is met with in every voluntary movement, as was first demonstrated by Piper. The irregular alternating current of some fifty periods per second is the electric phenomenon which

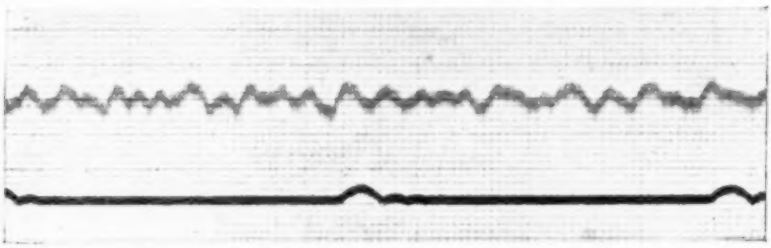

FIG. 3.—Voluntary tetanus. Time marks 0·2 second.

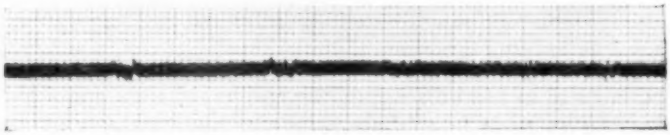

FIG. 4.—Myoclonic-epilepsy. Very short tetanus, nearly resembling simple twitches.

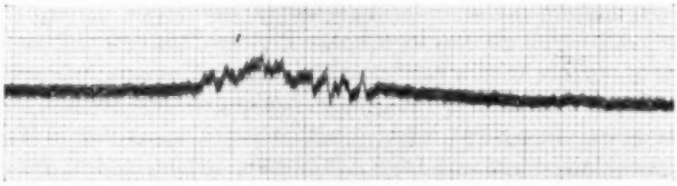

FIG. 5.—Electromyogram in normal plantar reflex. 100 mm. per second.

is typical of the tetanic contraction. If found in any contraction we may be absolutely sure that we have a tetanus before us. In cerebral contraction, such as epileptic convulsions, the string-galvanometer again shows the tetanic character of the muscular shortening. In two cases of myoclonic epilepsy I at first thought that I had at last found single muscle twitches of cerebral origin, but a closer examination of the

galvanometric records proved them to be also short tetani, the shortest I have ever seen. Many other different kinds of muscular action belong to this group, as the examination with the string-galvanometer proves. Such is the case with all cutaneous reflexes, as I had found many years ago. The duration of the tetanus may be very short, as short as 0·1 second, though generally it is much longer, yet we never fail to find the irregular oscillations of the string which indicate that the contraction was a real tetanus.

The third kind of muscle action is perhaps the most interesting. We may observe strong muscle spasms and also notable changes of the muscle tension without any electric action current. All changes in muscle tonus occur in this way and do not seem to cause any change in the electric state of the muscle. If the triceps brachii be connected to the galvanometer-terminals and the arms passively extended or bent, the string does not move. Yet the passive movement of extension is accompanied by a shortening of the muscle, the tonus-contraction. Similarly a tonus-relaxation does not act upon the string. In the case of myelitis with complete paralysis of the lower limbs, we may find enormous muscle spasms which do not show any action current. The same may occur in hemiplegia, lateral sclerosis of the cord, multiple sclerosis or generally in complete degeneration of the pyramidal tracts. I found them also in focal disease of the corpus striatum and regio subthalamica. In all these morbid conditions we have strongly hypertonic muscles. As far as we can judge, the absence of a typical action current seems to be the one and only means of differentiating between a tetanic and a tonic spasm or contraction. We should therefore use the Einthoven instrument in order to discover the nature of any muscle tension about which we are in doubt. Fröhlich and Meyer employed it for this purpose with a patient suffering from tetanus infection and found that the muscle spasms were tonic and not tetanic. I had occasion to examine a cat infected with tetanus by Professor Magnus, and easily obtained a record from the spastic triceps muscle showing a straight line interrupted only by small regular notches produced by the action current of the heart. On the other hand I found with Dusser de Barenne decerebrate rigidity to be a tetanic state. In veratrine poisoning we get a tonic muscle spasm, whilst strychnine poisoning produced real tetani, as was discovered years ago by Lovén and by Burdon Sanderson. Cataleptic muscle spasm is described by Fröhlich and Meyer as being of tonic origin, which does not seem to be in contradiction to an earlier investigation by Gregor and Schilder, whose

curves showed slight irregularities. As regards tetany in children and adults we have as yet no certain data. Two infantile cases which I examined did not yield satisfactory results and left me undecided as to the origin of carpopedal spasms. Yet I incline to the belief that these spasms are of tonic origin.

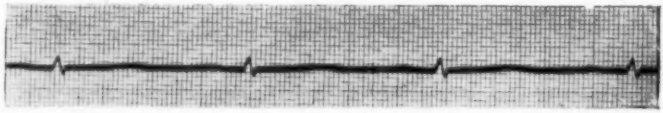

FIG. 6.—Tetanus infection. Electromyogram of triceps. 50 mm. per second.

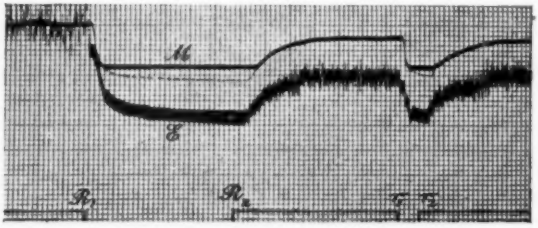

FIG. 7.—Decerebrate rigidity. M = Myogram. E = Electrogram. From R_1—R_2 stimulation of central nerve stump. After Einthoven.

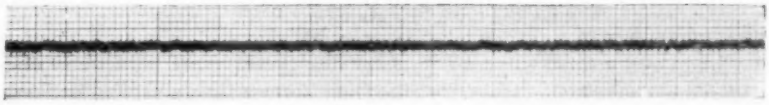

FIG. 8.—Infantile tetany. Action current in flexors of fingers. 100 mm. per second.

The question about the after-contraction in Thomsen's disease seems likewise to have been settled by Gregor and Schilder, who were not able to find the action-current typical of tetanus. I too have failed to find it, and therefore cannot agree with the recently published opinion of Schäffer who, after cessation of the voluntary tetanus, still found slight indications of an irregular oscillatory action-current which gradually tend to subside. I believe that these movements of the string are not caused by the tonically contracting muscles, but by the active contraction of the antagonists, which contract involuntarily to oppose the after-contraction.

An exceedingly curious kind of after-contraction was first described

under the name of "Katatonus-Versuch" by Kohnstamm in the *Neurologisches Zentralblatt* of 1915, but, as far as I know, has not yet penetrated into English medical literature. We can elicit this after-contraction in different muscles, but most easily in the deltoid. To do this, we should first voluntarily cause the muscle to contract isometrically with as much force as possible, and keep this up for perhaps a minute, the muscle being kept stretched all the time by fixing the arm. If then the voluntary impulse be stopped and at the same time the arm be released, we feel that the arm is drawn upwards, without, and even against, our will. Of course, we can easily prevent the arm being lifted, but if we try to remain absolutely passive, refrain from any voluntary impulse and just let the arm do what it seemingly wishes to do, it is lifted. The experiment succeeds equally well with

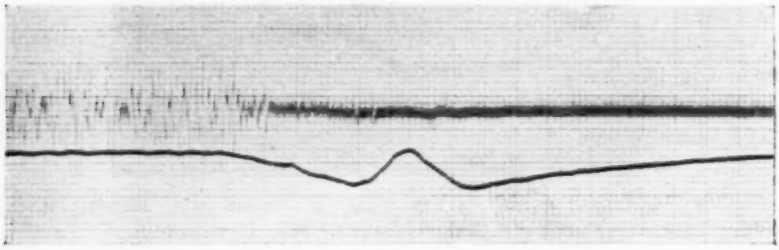

FIG. 9.—Katatonus experiment. Lower curve mechanical myogram. 50 mm. per second.

the hand extensors, whereas it is far less pronounced with most of the other muscles of the body. Csiky has shown that a strong prolonged faradic tetanization, during which the muscles are prevented from shortening, will also cause this after-contraction to appear. The duration of the after-contraction may be from one to ten seconds. This katatonus experiment has been ascribed to various causes. Kohnstamm thinks it may be an involuntary tetanus, whereas Csiky regards it as an idiomuscular contraction. If by this he means the same thing as what I call a tonus-contraction, I can agree with him, for examination with the string-galvanometer shows it to be an undoubted tonus-contraction.

There are many forms of hyperkinesis, regarding which we do not yet know whether they ought to be considered as tetani or tonus spasms. I shall not discuss these here, but shall give you later on the results I obtained in one particular field of research, namely, the reflexes. I have already mentioned that in normal deep reflexes we always get a simple

muscle twitch preceded by a diphasic action current, and that the knee and ankle clonus as well as the hand clonus in cases of sclerosis of the lateral tracts is composed of a regular series of simple twitches, each giving one single diphasic action current. Between each two successive electric impulses the muscle is electrically inert. But how is it with hysterical clonus? Here the galvanometric record shows the presence of a typical tetanus on which is superposed a series of somewhat stronger and probably not entirely regular diphasic action currents. It is generally assumed that the mechanical condition for the appearance of clonus demands an increased reflex-irritability and at the same time the presence of a certain amount of muscle-tension. Only the co-existence of both circumstances renders it possible for the muscle to contract clonically. With degeneration of the lateral columns this increased

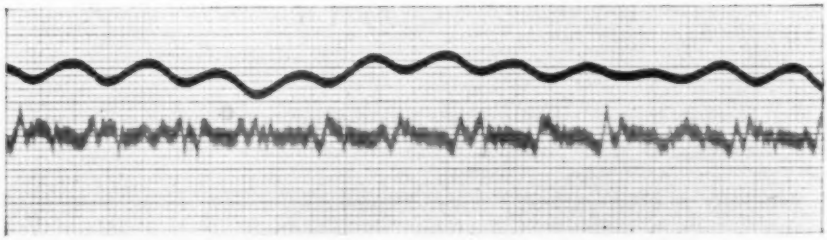

FIG. 10.—Hysterical knee clonus. 100 mm. per second.

muscle-tension is caused by increased tonus, whereas in hysterical clonus this is due to a tetanic muscular contraction. Although in general we shall not have any great difficulty with the differential diagnosis between organic and hysterical clonus, we may with advantage use the string-galvanometer for difficult or doubtful cases. We may probably even go a step further and say that the symptom here mentioned constitutes the only absolute and reliable symptomatical and genetic difference between the two conditions.

Frequently much definite and useful knowledge may be gained by simply recording the mechanical myogram in deep reflexes, especially when they are exaggerated. The normal knee-jerk gives a myogram which may best be compared to one from a gastrocnemius preparation of the frog. But as soon as we have to deal with exaggerated reflexes we hardly ever find this simple form. More often we find clonic contractions either in a short or in a longer series, each of the com-

ponents giving the well-known biphasic action current, in the same way as with the organic knee-clonus. In another group of cases we find that the initial twitch is followed by only one more contraction, which may commence after the principal jerk is entirely finished, but

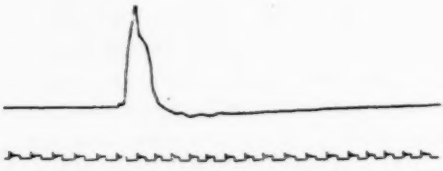

FIG. 11.—Knee reflex, simplest form.

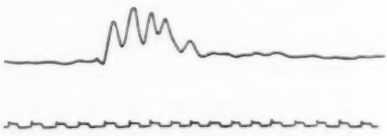

FIG. 12.—Knee reflex, simple clonic response.

FIG. 13.—Knee reflex, clonic after-contractions superposed on tonic secondary contraction.

generally a little earlier. This depends upon the duration of the first twitch, which generally lasts from 0·2 to 0·3 second, the second contraction usually beginning 0·25 to 0·3 second after the moment of percussion. Now, it is curious to notice that these double contractions may occur under widely different circumstances. I shall give a few instances.

We frequently find a double contraction in cases of chorea minor where its occurrence has already been described by Gordon Hey, Eshner, Kleist, generally as a lengthened response. This symptom was considered as a choreic movement following the reflex extension. The graphic record proves that the muscle invariably relaxes at least partially between the two contractions, and furthermore that the last regularly occurs after a definite latent period of 0·21 to 0·25 second. Its duration is not constant. Fahrenkamp has examined the action current and found the second twitch to be a tetanus. I found the same thing, so that we may take it as a fact that the knee-jerk is sometimes immediately followed by a second contraction of tetanic character. In several cases of sclerosis of the pyramidal tract the mechanical myogram of the knee-jerk also showed a double contraction not infrequently of different types.

In one kind the second contraction was an unbroken one of very short duration, although contractions lasting some 10 to 20 seconds may also be met with. In another type it appeared in the form of a series of clonic contractions from anything between two or three and a few hundred. Whereas this last clonic group was found to be electrically defined as an organic clonus, the first group did not give any deflection

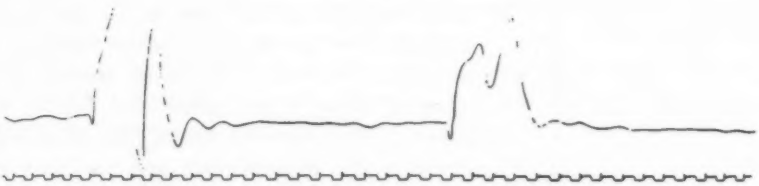

FIG. 14.—Knee-reflex in chorea. Double contraction.

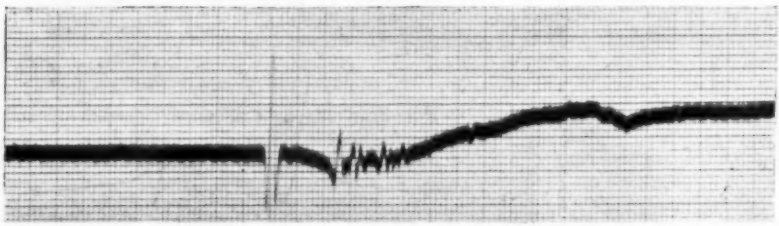

FIG. 15.—Knee reflex in chorea: Gordon Hey type. Action current of quadriceps. 100 mm. per second. Simple twitch followed by tetanus.

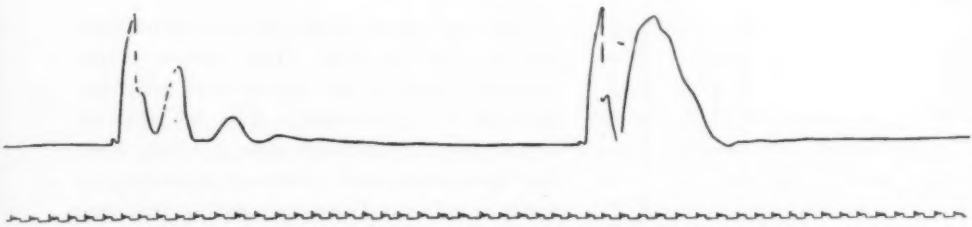

FIG. 16.—Knee-reflex in disseminated sclerosis. Double contraction.

of the string. This implies that the knee-jerk was followed by a longer or shorter tonus-contraction. But a point of interest is that we are able to produce at will in some patients either a tonic or a clonic after-contraction. We do this by only slightly modifying the way in which we support the knee of the patient; if necessary we can easily get

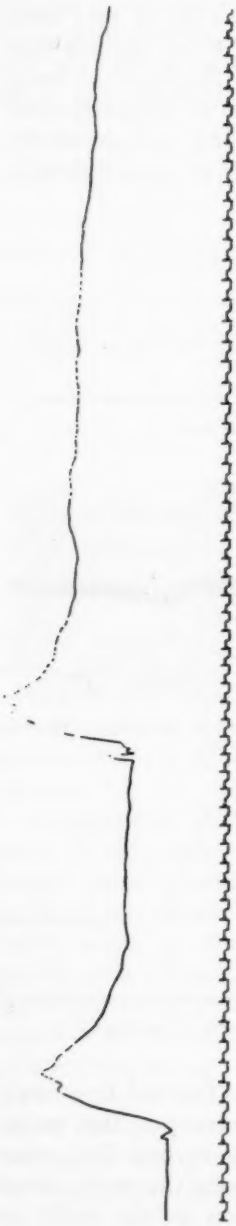

FIG. 17.—Tonic after-contraction of long duration in cerebral pseudobulbar paralysis.

alternately tonic and clonic after-contractions. This may be explained by first looking at the myograms. We see in both a tonic after-contraction. Now in order to get a clonus we have only to render the conditions for it as favourable as possible. If the upper part of the leg be immovably fixed the increase of tension in the quadriceps caused by the tonic after-contraction is sufficient to allow of the occurrence of a clonus. But if we allow the leg to be nearly fully extended during the after-contraction the tension does not rise so high as to permit of a clonus. The same is the case if the knee is bent much farther than is usual whilst provoking the knee-jerk.

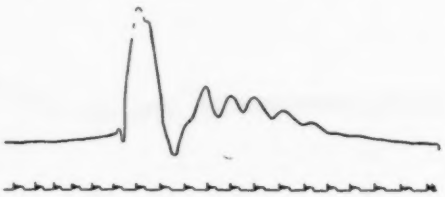

FIG. 18.—Knee-reflex, clonic after-contraction.

Muscle cut off from the central nervous system loses its tone. The normal maintenance as well as any variation of muscular tonus is a reflex action. The well-known Brondgeest experiment has probably been the first direct proof. As our knowledge of tonus is still far from complete, many have endeavoured to obtain a better insight into tone mechanism. Amongst those who have investigated the mechanical properties of normally innervated muscle substance as compared with those of muscle-protoplasm without tonus innervation, I must mention Langelaan of Amsterdam, who has contri-

buted a valuable paper on this subject in *Brain*. Professor Pekelharing in Utrecht was the first to demonstrate the chemical difference between ordinary contraction and tonus contraction. It is by the last that the creatine production is principally governed. De Boer has investigated the peripheral reflex mechanism itself and demonstrated that the centrifugal path probably lies along sympathetic nerve-fibres. Lastly, Boeke of Utrecht has found in all striped muscles new motor nerve-endings, which are not in connexion with the motor ganglion cells of the anterior grey substance in the cord. Personally I incline to the belief that Boeke's fibres, which undoubtedly are of sympathetic origin, conduct the centrifugal tonus impulses, though I am aware that Magnus and Dusser de Barenne do not share this opinion.

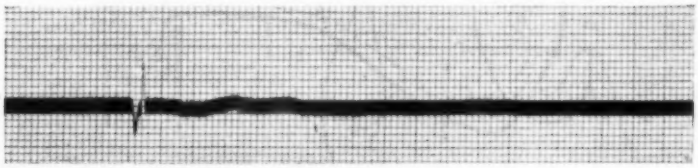

FIG. 19.—Electromyogram in knee-reflex with tonic after-contractions. Same case as fig. 17.

FIG. 20.—Knee-reflex with clonic and with tonic after-contraction.

The afferent reflex fibres, bearing the impulses from the muscle substance, pass through the posterior roots into the spinal cord, where they terminate in the lateral horns. From there a connector fibre passes through the anterior root, through the grey communicating rami into the sympathetic ganglion, where a third sympathetic neuron begins and returns to the motor nerve, where it runs parallel with the motor fibres to the muscle substance. Here it terminates in Boeke's end-organs. De Boer cut the grey rami communicantes in a frog and found the tonus to be diminished at the same side. A few days afterwards the muscle was stimulated by a single break shock of the induction coil. When the stimulus was applied to the spinal centre

the form of the muscle twitch was not the same as when the muscle was directly stimulated. In the former case the duration was shorter and the myogram showed the simplest and best known form. With direct stimulation the curve exhibited a secondary summit following the first one. De Boer considers this second elevation, generally known as "Funke's nose," as a tonus-contraction caused by direct

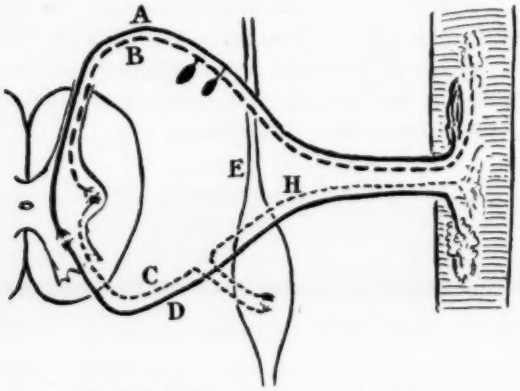

FIG. 21.—A and B, peripheral sensory neuron; C, peripheral connector neuron; D, motor neuron; H, sympathetic neuron; E, sympathetic nerve.

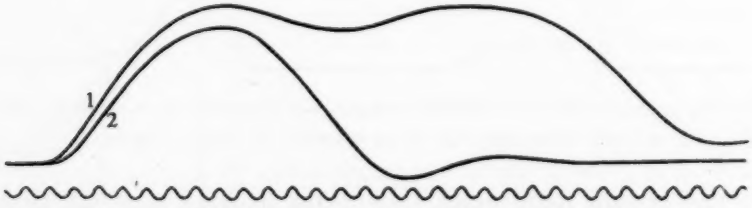

FIG. 22.—1, Contraction of gastrocnemius after direct stimulation of the muscle. 2, *Idem* after stimulation of the spinal cord, the rami communicantes having been cut five days before.

stimulation of tonus substance, at the same time as the anisotropous muscle substance is stimulated and contracts. This tonus substance can no longer be stimulated from the spinal cord after degeneration of the sympathetic fibres.

In the myogram of human muscles we practically always find the elevation of Funke; in hypertonic muscles the elevation is more plainly visible, as was clearly demonstrated by curves published by Mendelsohn

of Paris and Kollarits of Budapest. Both describe a spasmodic muscle contraction in which the tonus elevation dominates nearly the whole curve. We have seen the same thing in curves of the knee-jerks. We may therefore state that the knee-reflex is not so simple after all, but yet that it contains in itself the cause of a tonus-reflex. As this is also true of all the other deep reflexes we may say that a tendon-reflex is really composed of two superposed reflexes.

FIG. 23.—Tetani with sixteen and eighteen impulses per second; healthy man.

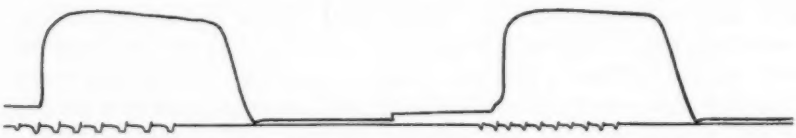

FIG. 24.—Tetani with ten and fourteen impulses per second. Disseminated sclerosis.

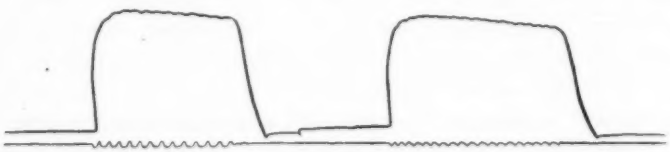

FIG. 25.—Tabes dorsalis. Tetani with 22 and with 24 impulses per second.

I can state here that the degree of tonus in human muscles has a considerable influence on the facility with which a complete tetanus may be provoked by faradic currents. Ratu Langi and I found that whilst in normal muscles about 18 interruptions per second of the induction coil were needed to elicit a complete tetanic contraction, hypertonic muscles gave a complete tetanus even with 10 or 12 interruptions per second. On the other hand, not less than 22 to 24 interruptions per second were needed with patients with locomotor ataxia whose muscles were quite atonic.

Let us now return to the patients with chorea minor in which the knee-reflex proper is followed by a shorter tetanic contraction. I have already remarked that this second part has a definite latency. This is

one of the reasons why I favour the opinion that we must not consider this tetanus as a voluntary contraction, but should rather regard it as a reflex contraction. This would imply that the knee-jerk has a third component—viz., a tetanic one. There are two other facts which seem to point to the same thing. In a few rare cases of tabes dorsalis or of chronic peripheral polyneuritis we find, on trying to elicit a knee-jerk, that the quadriceps contracts, but with a notably lengthened latency. This fact was observed and investigated first by Westphal, and is generally known as the pseudo-knee-jerk. Westphal regards this as a cutaneous reflex, and in some eight or ten cases in which I have seen this pseudo-patella-reflex I always found a constant though great latency of the order of 0·18 to 0·2 second. The other fact is that with many nervous persons the tapping of the patella tendon does not elicit a simple twitch but a jerk, immediately followed by convulsive extension of the whole lower limb. We can best explain these three different varieties of the knee tendon-reflex by assuming that not only a medullary centre but also a cerebral centre is provided for the knee-reflex. The reflexogenous zone for the central component extends over the part of the skin nearest to the patellar tendon. The centre itself is a secondary one of but little general use, and becomes active only under favourable circumstances, such as are found in patients suffering from chorea minor, or in highly-strung nervous persons, where either its excitability is increased or voluntary inhibition is diminished, or in rare cases of locomotor ataxia or polyneuritis, where it acts vicariously for the medullary knee-reflex centre. In character this cerebral knee-jerk is a skin-reflex with tetanic response. As the ordinary knee-jerk, which it should sustain and strengthen if necessary, is generally quite adequate and sufficient for its purpose, the action of the cerebral part of the reflex is hardly ever called for. Even when this might happen voluntary inhibition will generally prevent its activity, just as might happen in a minor degree with some ordinary inconstant skin-reflexes. Though this explanation permits of viewing a few widely different subjects from the same standpoint, I should have hesitated to accept it were it not that I had found the same thing with another group of reflexes which I described a few years ago under the name of shortening reflexes. If in some patients the relaxed foot is passively bent with a quick movement, so as to bring the ends of the tibialis anticus muscle nearer together, we sometimes observe a short contraction of this muscle. In the same way a passing contraction may be provoked in the semimembranosus, semitendinosus and biceps, if

the knee is passively bent somewhat rapidly. These contractions appear when the muscle is shortened, which proved to be the reflexogenous moment. Hence the name. The latency of these reflexes is extremely short: of the order of 0·04 second, which places them on a line with

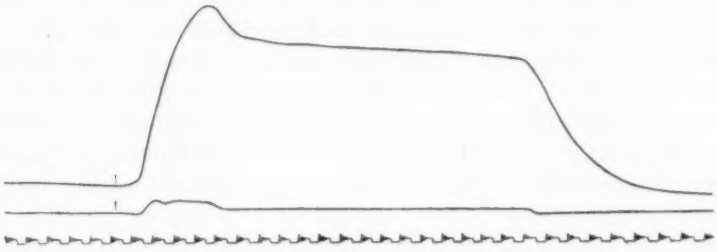

FIG. 26.—Shortening reflex in the tibialis anticus of a healthy man. Upper curve: passive displacement of the foot. Middle curve: contraction of tibialis anticus. Time marks of 0·1 second.

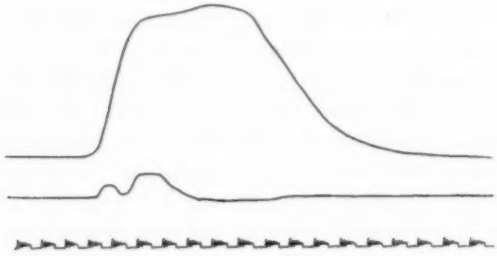

FIG. 27.—Shortening reflex of the healthy leg of a hemiplegic patient.

FIG. 28.—Shortening reflex of an oscillating type.

the tendon-reflexes. They also show the same peculiarities as the latter, being for instance accompanied by a tonus variation, to which the muscle twitch forms the introduction. In a few patients I was able

to record double contractions, as with the Gordon-Hey reflex. Rarely was a clonic after-contraction observed. These reflexes fail to appear whenever the tendon-reflexes are absent. But if these last are exaggerated, the same does not happen with the shortening reflexes. Curiously enough we find them generally easy to provoke in hemiplegic patients, not on the paralysed side but in the other leg. These reflexes show the same complexity as tendon-reflexes: first the tonus variation, and often the secondary tetanic component, showing them to have a cerebral centre too. If the activity of the cerebral centre be greatly increased the shortening reflex may change into Westphal's paradoxal contraction. I consider this last as a pathological variety of the shortening reflex if we except those cases in which it is of a cataleptic origin.

We have now to consider the cutaneous reflexes. These too I believe to be more complicated in the matter of the centre than we are taught in the text-books. This seems to be absolutely certain with respect to the defence reflexes from the skin, which generally possess a medullary and a cerebral centre. In animals the spinal centre is probably the more important one, whereas in man it is subordinate to the cerebral centre, which is generally located in the cortex. If this be destroyed the skin reflexes disappear, but usually reappear after a fairly long period and more often in slightly modified form or intensity. In several patients with section of the spinal cord where the post-mortem microscopical examination proved the section to be a complete one, I have seen the skin-reflexes return after an absence of six months (e.g., Brouwer). We may, and indeed ought to, assume a double centre for the skin-reflexes as well as for the deep reflexes, the difference being that in the cutaneous reflexes the more important activity belongs to the cerebral centre, whereas in the deep reflexes this is only a secondary centre of minor importance. That a tonus reflex also forms part of any skin-reflex need hardly be mentioned, as we cannot imagine a tetanic contraction without tonus reflex. This last is a positive one in the contracting muscles, a negative one in the antagonists.

In a few reflexes the complexity is still more pronounced than would appear from our discussion. The best example is perhaps the plantar reflex. In children who cannot yet stand or walk the plantar reflex, obtained by stroking the lateral side of the sole of the foot, is a pure protective reflex. The knee is bent, the foot is dorsally extended, in which also the long extensor of the great toe assists; frequently the whole leg

is drawn up. As far as the great toe, it shows the reflex type described by Babinski. But as soon as the child is able to walk a new reflex appears, in which the toes are flexed, as soon as the sole of the foot is stroked or pressed. Kalischer first pointed out that this new reflex is of great teleological importance. It causes the toes to be pressed against the floor as soon as the sole of the foot touches it, making the surface of contact as large as possible and rendering the conditions for standing or walking and for keeping the equilibrium as favourable as they can be made. Now the old extension reflex has not disappeared; it still exists but is invisible on account of the presence of the new and stronger reflex. The strength of the new reflex is probably to be found in the strength of the contracting muscles, as the toe flexors are stronger than the extensors in physiological condition. Consequently the preponderance of the action of the flexors over the extensor muscles practically renders the escape reflex unnoticeable. If the pyramidal tract has degenerated the toe flexion reflex disappears, only to leave the extension reflex of the Babinski type. How is this fact to be explained? Babinski, Kalischer and others speak of a disturbance of the physiological preponderance of the flexor muscles. But why should in pathological conditions the flexion be weaker than the extension if, normally, the extension was weaker? How can destruction of the lateral tracts cause this change? My answer to the question was that the explanation must not be looked for in the muscles themselves but in the behaviour of the different reflex-centres. Before giving a fuller exposition of my meaning, I may be allowed to say a few words on the muscle action in the Babinski reflex.

A mechanical record of the contraction of the extensor hallucis longus during a Babinski reflex shows that contraction is always a long one, somewhat resembling the slow contraction in reaction of degeneration, but mostly of still longer duration. If an electro-myogram be taken at the same time we can see better what happens. In this record on a plate moving 50 millimetres a second the electro-myogram shows an irregular alternating current lasting 0·66 second. About 0·14 second after the commencement of the action current the mechanical response begins, very gradually at first and only after 0·36 second very rapidly. The whole mechanical response takes not less than 2·7 seconds. In another record we see nearly the same thing. The time between the commencement of the electrical and the mechanical response is again about 0·12 second. The duration of the action current, or—what is the same thing—of the

purely tetanic part of the contraction, happens again to be 0·70 second, whereas the whole contraction takes over 3 seconds. In yet another electro-myogram the tetanus took only 0·11 second, though the total contraction lasted rather more than 2 seconds. These records prove

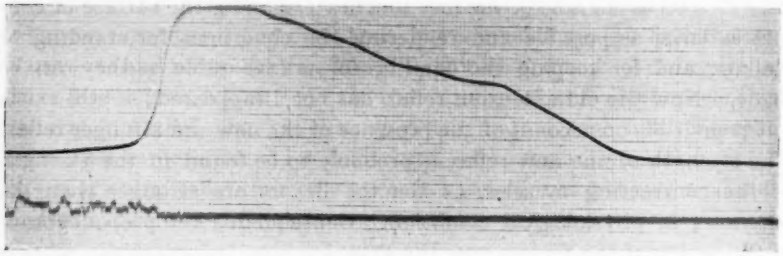

FIG. 29.—Babinski reflex. Myogram and electromyogram. 50 mm. per second.

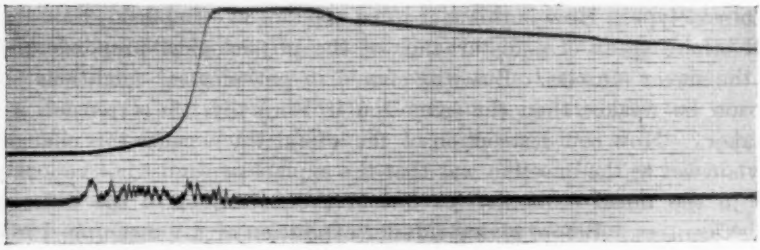

FIG. 30.—Babinski reflex. Myogram and electromyogram. 50 mm. per second.

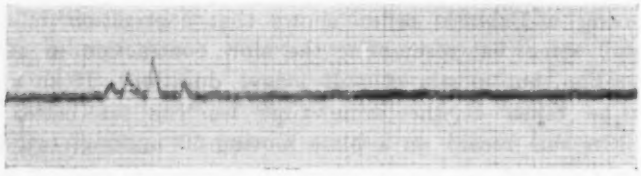

FIG. 31.—Babinski reflex. Electromyogram. 10 mm. per second.

that in the Babinski extension reflex, too, the tetanus is the beginning of the reflex which is immediately followed by a tonus-contraction. But they also show that the tetanus, which is the real primary reflex, is not sufficient in itself to cause more than a hardly perceptible movement of the hallux; it is the tonus variation that causes the

extensive movement. I need scarcely add here, that I never succeeded in getting the tonus-contraction without the tetanus. Clinical examination of the patients from whom these records were taken proved that the tonus of the muscle of the hallux during rest was not greatly changed; a passive flexion or extension of the hallux met with almost the same rather small resistance. Apparently it was not the tonus itself which was exaggerated, but the irritability of the tonus-reflex mechanism. With normal muscles we never find anything of this kind. As soon as the action current disappears the contraction ceases. Only in muscles very nearly exhausted—as we have already explained at some length when discussing the katatonus experiments—do we get after-contractions of tonic origin. Consequently there can hardly be any doubt about the interpretation of these curves.

Before returning to the question of the plantar reflex, I must point out that the centres of the phylogenetically old reflexes are situated in the spinal cord. The younger a reflex is phylogenetically, the higher up in the cerebro-spinal system must we look for its centre. Where two or more centres are present we may expect that the oldest centre will be found in the lower part of the central nervous system, generally in the spinal cord.

Let us now return to the plantar reflex. The reflexogenous zone is the sole of the foot. As part of the integument it possesses in the first place the property, belonging to any part of the skin, of being the reflexogenous zone for a protective reflex. This is a phylogenetically very early reflex with a low spinal centre. In man this spinal reflex is not adequate and it has to be assisted and restrained by cerebral impulses—involuntary as well as conscious ones—undoubtedly in a far higher degree than in animals. But this means the development of a cerebral centre which gains in importance the higher up we look in the animal series, till we arrive at man, where it has attained far greater importance than the original spinal part of the reflex.

The sole of the foot is at the same time the reflexogenous zone for the toe-flexion movement, the reflex needed for walking and standing. This reflex develops only as the child learns to stand and walk, and we may even say that the act of learning to stand is the same thing as the gradual acquisition of the reflex. As standing and walking only take place after a cerebral impulse and are only possible by continuous cerebral impulses, the whole mechanism of these actions comes very near to being a complete cerebral automatism. As soon as the cerebrum directs the foot to touch the floor toe-flexion appears as

the consequence of a phylogenetically late and consequently cerebral reflex. Now we also see why teleologically the toe-flexion reflex should be stronger than the protective toe-extension reflex in normal man. If this were not so, walking would be extremely difficult, not to say impossible, as with each step the toes would be lifted from the floor instead of being spread so as to enlarge our contact with the earth. That is the reason why the act of learning to walk is largely synonymous with the acquisition of this reflex. Even the age of the child is immaterial; in rare cases where children learn to walk at a more advanced age, as in late rickets, the original Babinski type of the plantar reflex persists till the child is able to walk. But as soon as this happens the flexion type of the plantar-reflex is provoked by touching the floor with the sole of the foot as well as by striking it.

Starting from these considerations we arrive at a plausible explanation of the Babinski reflex in lateral sclerosis. As the centrifugal impulses for the plantar reflex pass through the pyramidal tract, the cerebral centre is put out of action. But the spinal centre and its efferent and afferent paths remain intact, certainly for the toe-extension reflex, and if a spinal centre for toe-flexion exists, for this centre also. The activity of the spinal toe-flexion centre, which is a phylogenetically late reflex, need scarcely be considered as compared with the significance of the centre for the extension of the hallux, which is a very early reflex in phylogenesis. And though even the activity of this last centre is relatively small as compared with its own cerebral component, it is readily redeveloped. Consequently toe-extension reappears, though not in a very pronounced form. As at the same time the secondary tonus reflex is greatly increased owing to the enhanced irritability of its spinal centre, which is no longer controlled by the higher tonus-centres, we finally get an ample dorsal extension of the toe.

Summary.

In this lecture I have tried to demonstrate the advantage to be derived from the use of the string galvanometer in clinical neurological research, where it can differentiate the several modes of muscle contraction. Graphic records of the electrical and mechanical responses in human muscles show both the innervation and the mode of contraction to be a double one. We have to distinguish between a tetanic and a

tonic innervation as well as between contractions of tetanic and tonic character.

The graphic study of reflexes proves them to be much more complicated than is generally understood to be the case. The complication arises from the fact that every simple or tetanic reflex is in itself the cause for a secondary tonic reflex. Moreover most reflexes are governed by more than one centre. Application of these principles has been made to explain the genesis of the Babinski form of the plantar reflex.

Proceedings of the Section of Neurology of the Royal Society of Medicine.

President—Dr. Ernest S. Reynolds.

In the Chair—Dr. W. Aldren Turner, C.B.

Meeting held October 7, 1920.

Aphasia: An Historical Review.

(THE HUGHLINGS JACKSON LECTURE FOR 1920.)

By Henry Head, M.D., F.R.S.

The evolution of our knowledge of cerebral localization is one of the most astonishing stories in the history of medicine. Throughout the Middle Ages the brain was supposed to contain three ventricles, each of which was the dwelling place of one or more aspects of the psyche [19]. The anterior chamber received the nerves of taste, smell, sight and hearing, and was the seat of the "sensus communis"; in the middle ventricle dwelt the faculty of cogitation and reasoning, whilst the posterior one was the seat of memory.

Under the profound influence of Descartes and his followers the vivid intellectual life of the seventeenth and eighteenth centuries swept away all traces of this scholastic materialism. Many guesses were made, but no satisfactory theory was evolved to account for the relation of mind and body; even as late as 1798, Soemmering thought the seat of the soul was in the fluid which filled the ventricles. No one presumed to imagine that the activities of the mind bore any direct relation to the life of the brain. Gall first suggested that this apparently uniform mass was made up of organs which subserved the manifestations of the vital and moral faculties of man. These could be divided into three groups: (1) Those concerned with the exercise of "vital force," which he located in the upper part of the spinal cord and medulla oblongata; (2) the "inclinations and affections of the soul," situated in the basal

portions of the brain, and (3) the "intellectual qualities of the mind," associated with the cerebral hemispheres.

We habitually think of Gall with derision, as a quack who was responsible for phrenology and the study of bumps on the head. But it is to this man that we are really indebted for the beginning of the conceptions we now hold of the relations of the various portions of the nervous system to one another.

Franz Joseph Gall was born on March 9, 1758, at Tiefenbronn, in Baden. He studied medicine in Strasbourg, and in 1781 settled in Vienna. From 1796 to the end of 1801 he lectured on a new theory of the functions of the brain. His views were considered so subversive of religion and morals, that on December 24, 1801, his lectures were forbidden by an autograph letter of the Kaiser. Gall seems to have remained in Vienna for the next three years, and then journeyed through Europe with his pupil Spurzheim, lecturing as he went [10]. In 1807 he reached Paris, and in the following year presented a memoir to the Institute of France, entitled "Introduction au Cours de Physiologie du Cerveau." On this treatise a committee specially appointed drew up an unfavourable report. Gall and Spurzheim in 1809 published their "Recherches sur le système nerveux en général et sur celui du cerveau en particulier," which comprised a categorical examination and reply to the objections of the committee's report [11]. This was their first serious publication in French, and it contains all the views put forward by Gall at one time or another. Subsequently he issued in Paris a full account of his work in eight volumes, with an atlas of a hundred plates [12].

The doctrines of Gall had an enormous influence upon the thought of his time; but the only part of his theory which we attribute to him in the present day is the idea that the underlying structure of the brain has an effect upon the formation of the skull, and in consequence that character could be foretold from the external conformation of the head. But in reality this is but a small part of the theory put forward by Gall. He was the first to insist that the brain should be examined anatomically from the spinal cord upwards; for he laid down that the functions of the brain could only be explained by considering their relations to those of the spinal cord. All nerve fibres ended in grey matter, and the white matter of the nervous system served for conduction only. He pointed out the analogy between the grey matter which covers the hemispheres of the brain and of the cerebellum, with that which forms the corpora quadrigemina and optic thalamus. All

nerves, whether they belonged to the brain or to the spinal cord, took their origin in grey matter, and the substance of the cerebrum and cerebellum could not be considered to be in direct connection with the peripheral nerves.

These ideas have been accepted into the body of general knowledge, but they were accompanied in Gall's exposition by the most fantastic theories with regard to the "moral" qualities. He pointed out that injuries to the head showed that the mind was associated with the brain, and that the brain serves as the organ of intellectual life. The nervous system of man was therefore the physical instrument of his moral life, for the nerves were the conductors by which the will was transmitted to all parts of the body. Then he set about to consider in what parts of the brain were situated the various moral and intellectual qualities of man. At that time it was supposed that man was endowed with certain "faculties," and it was these that Gall attempted to localize in different parts of the brain. He found the organ of the generative force in the cerebellum, and those of the five senses over the front portion of the brain. There were six different forms of memory, each of which he localized in a different "organ," or as we should say "centre." There was the memory of things, the memory of locality, the name-memory, the verbal and grammatical memory, and the memory for numbers. All of these were situated in those portions of the brain which lay in relation with the posterior part of the orbital cavity. It would seem that this localization dated back to Gall's earliest years; for as a boy he noticed that his companions who had "des yeux pochetés" (prominent eyes) had a gift for languages and a memory for words. He therefore concluded that the parts of the brain which pushed the eyes forward must be associated with the different varieties of verbal memory. Translated into anatomical terms, this meant that the frontal lobes and particularly their under surface must be devoted to these forms of memory.

He appears to have taken no precautions to verify this localization, but he had the opportunity of seeing an officer in whom a foil had passed through the base of the frontal lobes, producing grave disorders of speech. He gives a very short description of this case, but seems to look upon it simply as confirmatory evidence of his theory.

Gall died on August 22, 1828, and gradually most of his views passed into oblivion or came to be treated with derision; but his conception that speech and the memory for words were situated in the frontal lobes still found supporters. Its warmest champion was

Bouillaud, who was appointed Professor of Clinical Medicine at the "Charité" in 1831, and at the time that Broca made his first post-mortem was 65 years old, and the "doyen" of the faculty. He was an ardent follower of Gall, and offered a sum of money to anyone who would produce the brain of an individual who had lost his speech in which the anterior lobes presented no lesion.

In 1861 Broca had just become the head of the Surgical Unit at Bicêtre. An elderly man was admitted to his wards (aged 51) with a diffuse gangrenous inflammation of the right lower extremity. He was completely aphasic, and died a few days later; Broca demonstrated the brain at the Société d'Anthropologie, of which he was the secretary [5]. This brain showed destruction of the posterior part of the second and third frontal convolution, the inferior portion of the Rolandic area and the first temporo-sphenoidal convolution. It was preserved in the Musée Dupuytren, and was subsequently examined more carefully by Pierre Marie [16, No. 3], who has pointed out that the lesion also occupied the supramarginal gyrus, a part which at that time was not considered of any importance from the point of view of speech. This was followed by a second case [7] in which the situation and nature of the lesion was acknowledged to be more doubtful (November, 1861). This brain also has been examined by Pierre Marie, who could find no lesion of the third frontal convolution; but there seems to have been some wasting at the foot of the second frontal convolution, which is not uncommon in a senile brain. Broca himself says that this lesion is incomparably more circumscribed than that of the first brain, but he continues, "In comparing the two specimens it is possible to make certain that the centre of the lesion is identically the same in the two cases."

As may easily be imagined, these communications led to the greatest excitement in the medical world of Paris. Bouillaud, and his son-in-law Auburtin, greeted Broca as a convert to the doctrines of Gall. The localization of speech became a political question; the older conservative school clung to the conception that the brain "acted as a whole," whereas the younger liberals and republicans passionately favoured the localization of function. For the next few years, every scientist of importance in Paris took one side or the other. Trousseau brought the weight of his authority into the scale on the side of Broca, and invented the word "aphasia" to replace Broca's "aphemia." This was an unjustifiable change in nomenclature, which as Broca complained "brought back into pathology the very confusion I thought to dissipate."

Broca described aphemia as follows: "There are cases where the general faculty of language persists without alteration, where the auditory apparatus is intact, where all the muscles, without excepting those of the voice and articulation, obey the will, and where in spite of this a cerebral lesion abolishes articulate language; this abolition of speech in individuals who are not paralysed or idiots constitutes a symptom sufficiently singular to be given a special name. I shall give it the name of 'aphemia' because what is wanting in these patients is solely the faculty of articulation. They hear, they understand all that one says to them; they have their intelligence, they can emit vocal sounds with ease; they can execute with the tongue and cheeks movements much more energetic than those required for the articulation of sounds. Moreover, the answers they can make are reduced to a very few articulated sounds, always the same and always disposed in the same manner. Their vocabulary is composed of a short series of syllables, sometimes of a monosyllable which expresses everything, or rather it does not express anything, because the single word is often foreign to all vocabularies. Some patients have not even this vestige of articulated language; they make vain efforts without pronouncing a syllable" [6].

Broca had discovered a definite clinical condition, which he called "aphemia," produced by destruction of the substance of the brain, and he believed that he had found the seat of the faculty of articulated language in the third frontal convolution.

Interest in the question of localization of speech rapidly spread to England, and in 1864 Hughlings Jackson published his first paper on "Loss of Speech with Hemiplegia of the Left Side" [14, No. 2]. This was followed by a series of contributions on the subject in which many other physicians joined.

In 1868, the British Association for the Advancement of Science held its Annual Meeting at Norwich, and M. Broca opened a discussion on aphasia. He was followed by Dr. Jackson. No record of these contributions is to be found in the *Proceedings of the British Association*, but Broca's paper was published in the *Tribune Médical* [8].[1] An abstract of Jackson's paper appeared in the *Medical Times and Gazette* for September 5, 1868. This has been reprinted amongst the collected papers in *Brain* [14, No. 17].

[1] I was unable to find this paper in London and owe my knowledge of its contents to the kindness of Professor Pierre Marie, who caused a copy to be made by hand. This he presented to me in memory of his master, Broca, for whom he acted as Interne in 1880.

Thus, we are able to compare the views of the French and English protagonists of localization, and it is no wonder that at that period, and, under those conditions, Jackson's views produced little serious effect. Broca is clear, definite and precise, and I shall therefore begin this stage of the history by summarizing his views.

He divides affections of speech of central origin into two main groups —"Aphémie" and "Amnésie verbale," and lays down clearly the difference between them. The aphemic patient has a profoundly reduced vocabulary and may be speechless, except for some monosyllables, oaths and words that do not seem to belong to any language. His ideas are intact, as shown by gestures, and he can understand what is said to him and recognizes words and phrases which he cannot pronounce or even repeat. On the other hand, the amnesic patient no longer recognizes the conventional associations established between ideas and words. He can pronounce them, but they do not seem to have any bearing on the ideas he wishes to express. He is able to show by gestures that he has not lost all kinds of memory, but it is the special memory, not only of spoken but of written words, that is lost.

So far Broca's statements are admirably clear and consonant with fact. When however he tries to determine the site of the lesions responsible for these conditions, he becomes confused and indefinite. He saw clearly that the larger number of cases did not correspond to these two clean-cut divisions. In practice, both states can exist together and this greatly hampered the determination of the position of the lesion. He utters a wise warning on the necessity for drawing conclusions from selected cases only, and insists that it is "aphemia" which is caused by a lesion of the third frontal convolution.

Let us now turn to Hughlings Jackson's contribution to this discussion. He said nothing about localization beyond referring to his previous papers. As far as can be gathered from the summary [14, p. 59], he confined his attention to the nature of the loss of speech produced by cerebral lesions. He pointed out that healthy language consisted of two inseparable, yet distinct, forms: (1) Intellectual—i.e., the power to convey propositions; (2) emotional—i.e., the ability to exhibit states of feeling. These two are separated by disease. It is intellectual language alone which suffers in most of these cases; emotional language usually escapes altogether. Cases of affection of speech can be divided into two groups, in the first of which the patient is speechless, or nearly so; whilst in the second, he has plenty of words but uses them wrongly. He denied that there was such a thing as a

"faculty of speech" or a "faculty of memory," and says "The question is not, how is general mind damaged, but what aspect of mind is damaged?"

Thus, he laid down in this discussion the fundamental basis of the whole of his future treatment of the subject. It is the power to form propositions that is affected, and not the memory of words or faculty of language. The higher the propositional value of the task the patient is asked to carry out, the less he will be able to respond; whereas, the lower or more automatic the action required, the easier will it be to perform.

But subsequent investigators took no care to emulate the clinical acumen of Broca or the psychological insight of Hughlings Jackson. Bastian published his well-known paper in 1869 which had such an evil influence on the subsequent course of the discussion. He started from the *a priori* assumption that we think in words, and that words are revived in the cerebral hemispheres as remembered sounds. He talked of lesions of special fibres and centres, and set the points on the catastrophic road to schemas and diagrams. His subsequent Lettsomian Lectures [3], re-published in 1898 under the title "Aphasia and other Speech Defects," had, as a frontispiece, the famous diagram so often cited in subsequent discussions [4]. This book is little more than a widely expanded version of his original paper, and by its simplicity and dogmatism seduced the younger generation away from the difficulties and complexities of Jackson's doctrine.

The first actual diagram was published by Baginsky in 1871 [1], who like most of the Germans was unaware that Bastian had already described word deafness. From this time onwards the rage for diagrams became a veritable mania. No one could write on aphasia without producing a new diagram of centres and the paths between them. Each author twisted the clinical facts to suit the lesions he had deduced from his pet schema. Wernicke in 1874 [21] localized the centre for auditory images in the first left temporal convolution, but would allow no centre for reading and writing; oral speech alone possessed cortical centres, one of which was guiding and the other emissive. Between these two lay the island of Reil, and three main forms of aphasia must therefore be possible. The first of these was sensory, and the lesion was situated in the temporal convolution. The second was motor and the lesion lay in the third frontal convolution. The third variety was due to interference with conduction between these two centres.

How far the writers of this period were compelled to lop and twist the clinical facts to fit the procrustian bed of their hypothetical conceptions is shown by the famous case published by Wernicke in 1903 as "A Case of Isolated Agraphia" [22]. Now, such a title can only mean that in this patient every other act of language could be perfectly performed, except that of writing. But when the record of the case is examined, the patient appears to have had much difficulty with spontaneous speech, and in understanding what was read. She could not comprehend many spoken words, nor could she carry out commands given verbally. She is said to have shown almost complete inability to write, and it was with great difficulty she could be brought to make the attempt. She was also unable to draw to command, although she could copy drawings and writing, and she failed to say the days of the week or the months in their proper order. In the solemn discussion which follows, on the nature of disorders of speech, it is difficult to decide whether the clinical obtuseness or want of theoretical insight is more worthy of wonder.

Amongst the various diagrams that of Lichtheim [15] attained the greatest popularity. It was definite and precise; every form of aphasia was accounted for by a lesion of some hypothetical centre or purely imaginary path. Teachers of medicine could assume an easy dogmatism at the bedside and candidates for examination rejoiced in so perfect a clue to all their difficulties. But serious students could not fit these conceptions of aphasia with the clinical manifestations; incredulous of such scholastic interpretations, they lost interest in a problem of so little practical importance.

In 1906, Pierre Marie startled the medical world by three papers in the *Semaine Médicale* on "Revision of the Question of Aphasia" [16]. The first of these bore the aggressive title, "The third left frontal convolution does not play any special rôle in the function of language," whilst the third was a fascinating historical essay on "Broca and his times," together with an account of the re-examination of the hemispheres of his two first patients. This was followed by a series of papers on the subject of aphasia and its cerebral localization, culminating in the monograph of Moutier which appeared in 1908 from the laboratory of Pierre Marie at Bicêtre [17].

Marie laid down that the aphasia of Broca was not a clinical entity but a "syndrome." It is a combination of two distinct troubles which he called "anarthria" and "aphasia." By "anarthria" he understood simply the inability or difficulty of articulating words. On the other

hand, aphasia was the sensory aphasia of Wernicke, characterized by troubles of internal language, which showed themselves directly in alterations of speech, reading and writing. There is nothing of aphasia in the motor trouble of the anarthric. He understands, he reads and he writes. His power of thinking is intact, and expression is possible by every other means except words, internal language remaining unaltered. There is only one aphasia, the aphasia of Wernicke, and the term "sensory aphasia" must disappear.

But the greatest excitement was produced by Marie's views on the cerebral localization of the lesion responsible for these defects of language. Of the two factors which constituted the aphasia of Broca, the anarthric aspect was due to a lesion of the "lenticular zone" whilst the aphasic side was produced by one in "Wernicke's zone." This latter was not a special loss of word memories, but was a defect of general intelligence, and of special intelligence of language.

In Moutier's monograph, "L'Aphasie de Broca," he gives an interesting history of our knowledge of aphasia, followed by a reconstruction of the nature and symptoms of this disorder from the point of view of his master, Pierre Marie. One of the most valuable portions of this book consists in a series of reports, both clinical and pathological, of a large number of cases. The second part is prefaced by a scheme of examination which is singularly complete.

By this time the differences of opinion in Paris had become so acute, that three sittings of the Société de Neurologie de Paris (June 11, July 9, and July 23, 1908) were devoted to a discussion of this question [9]. Unfortunately, though an attempt was made to keep the clinical and pathological aspects apart, this was impossible in practice. Two questionnaires were prepared to serve as the basis for discussion. The first of these was divided into "Étude anatomique" and "Étude clinique," whilst questionnaire B consisted of three portions: (1) "Clinique"; (2) "Anatomie normale et pathologique"; (3) "Physiologie pathologique." The second of these was accepted as the basis of discussion, which began as follows: "Are motor and sensory aphasia clinically different from one another, or is motor aphasia sensory aphasia accompanied by anarthria? If there are differences, what are they?" Unfortunately this led to a discussion based entirely on terms such as "Broca's aphasia," "total aphasia," "word blindness," "word deafness," "alexia," "agraphia," &c. Marie held strictly to the views set out above, whilst Dejerine defined his position as follows: "The aphasia of Broca is a motor aphasia and total aphasia is both sensory

and motor. The aphasia of Broca is accompanied by a loss of words, marked trouble in writing, some alexia, though not excessive; the patient is able to transcribe print into handwriting. On the other hand the sensory element consists in word deafness and word blindness.

Dejerine attacked the use of the word "anarthria," which should, he contended, be kept for definite troubles of articulation. Marie represented that he had chosen this word because cases of mere motor aphasia showed no disturbance of internal speech.

Dupré and others insisted that the motor aphasic had difficulty in evoking his words. Aphasia is a psychical defect and trouble of language ("langage"); anarthria, on the other hand, is a motor defect and a trouble of speech ("parole"). Marie answered that the anarthric had no trouble in evoking a word, but solely in pronouncing it, and he agreed to substitute the word aphemia for anarthria, provided the meeting would acknowledge that the phenomenon was not associated with a defect of internal speech.

The next sitting and the first half of the final sitting were devoted to an attempt to settle the situation of the lesion responsible for the various forms of aphasia. But, as no satisfactory clinical definition had been arrived at during the earlier phase of the discussion, the greater part of the time was spent in discussing the limits of Marie's lenticular zone and its justification. Finally, the meeting turned to a consideration as to whether there were disturbances of intelligence in motor aphasia, and if so, what form they took, and secondly, whether intelligence was disturbed in sensory aphasia. At this stage, Marie brought forward his views on the evident diminution of general intellectual capacity, which is found in those cases which he describes as the "aphasia of Broca." This is in no sense a dementia; he insisted on the exactness of the terms that he had used. "Il y a une diminution très marquée dans la capacité intellectuelle en générale" (p. 1037). This intellectual disturbance is a specialized defect. He admitted that the "zone of Wernicke" is the part where a lesion produced with certainty troubles of language, but he denied independent existence of special sensory word centres which had been attributed to this portion of the brain.

Marie fought hard for simplification and made a bold attempt to sweep away the vast accretion which had obscured the question of aphasia; but no one ventured to suggest that the greater part of the discussion of the clinical manifestations was purely a verbal battle. Had the disputants been familiar with the work of Hughlings Jackson, they would have recognized that, from the point of view of the question

at issue, all these terms such as "aphasia of Broca" "total aphasia," "word blindness," and "word deafness," were pure phrases, and did not in reality correspond exactly to any clinical phenomena.

I have kept the views of Hughlings Jackson until the last, because his attitude towards the question was entirely foreign to any conception put forward in the history of aphasia. His views bore no fruit during his lifetime for two reasons. Firstly, they were published in a series of papers between 1864 and 1893, many of which were inaccessible on the Continent. Secondly, the style in which they were written makes them peculiarly difficult to read. He was so anxious not to overstate his case that almost every page is peppered with explanatory phrases and footnotes, so that the generalization can scarcely be distinguished from its qualifications. English students, accustomed to the fluent dogmatism of his contemporaries, turned away from the bristling difficulties of Hughlings Jackson's papers. Finally, the ideas he propounded were entirely opposed in their nature to the current opinions of the day. No one assimilated his views on defects of function and applied them to actual cases of loss of speech. We failed to appreciate how much closer these conceptions would have led us to the phenomena of aphasia than the glib generalities founded on the supposed anatomical facts of cortical localization.

When however I became interested in working out the problem of aphasia in the light of our researches on the effects produced by cortical lesions on sensation, it became obvious that none of the current doctrines corresponded to the clinical facts. I set to work to make a collection of Jackson's papers on the subject, and was startled to find that he had long ago arrived at several of the general conclusions which had led me to disbelieve the teaching of my contemporaries. In 1914, Pick's remarkable book, "Die agrammatischen Sprachstörungen" [18] fell into my hands and determined me to republish Jackson's papers on aphasia in *Brain* [14].

In spite of its occasional obscurity Jackson's work is of peculiar importance to the neurologist of to-day, both as a practical guide to the clinical phenomena of aphasia and an understanding of the processes which underlie the production of speech. His views can be summed up shortly as follows:—

(1) In 1868, he pointed out that patients with aphasia can be divided into two main groups. In Class 1 the patient was almost speechless or speech was gravely damaged, but in the worst of these cases the patient

could utter some one or two unvarying words or jargon. Class 2 comprises those who have plentiful words but habitually use them wrongly.

(2) The loss of power to carry out an order depends on the complexity of the task. The more abstract the conception, the more likely is the patient to fail in executing it, although he may succeed when it is put before him in a simpler and more descriptive form. Thus, the patient who could not find the word "kitten" called it "a little fur child," and one who could not draw a square when asked to do so, drew a perfect square when told to draw a block of wood. Thus, it is most important, when asking an aphasic patient to carry out some order, to present it to him if possible in several forms, noting his response in each case; because a man cannot write the alphabet, we must not assume that he cannot write a letter.

(3) The higher and more voluntary aspects of speech tend to suffer more than the lower or automatic. The least voluntary speech is that which is emitted under the effect of emotion, such as exclamations, oaths, and words such as "good-bye," rising to utterance under the impulse of a moment. In many cases "yes" and "no" can be used approximately as propositions, and even words and phrases of true propositional value may spring to the lips of the aphasic patient. But in such cases he is usually unable to repeat at will the phrase he has just used under an appropriate impulse. The "speechless man is not wordless," and the apparent inconsequence of observations on persons with aphasia is to a great extent removed by an analysis of the conceptual value of the words and phrases which are actually uttered.

(4) Writing is affected, not as a separate "faculty" but as a part of the failure to propositionize in words. There is no such condition as pure "agraphia." A man who cannot write spontaneously may be able to copy printed matter in perfect handwriting. The "faculty" of relating handwriting to print is intact; he cannot write voluntarily because he has lost the use of written words in propositions. Hence, he can usually write his name and address, because in most of us this has reached with time more nearly the level of an automatic act.

(5) Patients with such affections of speech may not be able to read aloud or to themselves, when asked to do so; but they can understand what is read to them and may even obey written commands, although unable to reproduce them in words. This is not due to some loss of function called "alexia," but to an inability to reproduce a proposition which, on the other hand, they may be capable of receiving accurately.

(6) "Imperception" is on the receptive side what aphasia is in the

"word series." In many cases the two conditions are combined; but they may exist separately, and, where aphasia is present without "imperception," images remain intact. Thus the patient may be able to point to colours and objects when they are named; he continues able to play cards or dominoes; he recognizes handwriting, although he cannot read the words written; he knows poetry from prose by the different endings of the lines on the right of the page.

Thus, affections of speech are caused (*a*) on the emissive side by inability to form or to express a proposition in words; (*b*) on the receptive side by failure of those mental processes which underlie perceptual recognition.

(7) External and internal speech are identical, except that one leads to the utterance of articulated words, whilst the condition of internal speech can be discovered by writing only.

(8) Behind external and internal speech stands the proposition which, when verbalized, can be expressed in speech or writing. This proposition is necessary for clear and logical thought, but not for all thinking. When this aspect of speech is affected, the patient cannot retain a sequence of abstract propositions, because he is unable to formulate them at will to himself. He can think, but he is "lame in thinking."

(9) If, however, "imperception" is added to such defect of speech the patient will not only suffer from "inferior speech," but will show signs of "inferior comprehension."

(10) In the majority of cases of affections of speech mental images are unaffected. This extremely important contribution to the theory of aphasia has been entirely neglected by neurologists. For almost every hypothesis propounded in the last forty years presupposes some defect in "auditory" or "visual word images."

In 1910, it became obvious to me in the light of our work on the part played by the cortex in sensation, that new tests must be devised before the clinical investigation of aphasia could produce any satisfactory results. It is not sufficient to hold up some object and ask the patient to name it; at one time he may be able to do so, at another he fails completely. No conclusion can be drawn from one or two questions put in this way. His power of responding must be tested by a series of observations in which the same task occurs on two or more occasions.

Not only is it necessary to arrange the tests in sequence, but each set must be put before the patient in several different ways. For example, six common objects are laid on the table in front of him, and

he is asked to point to the one which corresponds to a duplicate placed in his hand out of sight. This is repeated for from eighteen to twenty-four observations, so that the choice of any one object recurs three or four times in the course of the series. Then he indicates each one in turn as it is named by the examiner, or makes his selection in answer to printed words set before him on a card. He next gives names to the various objects, one by one, and finally writes them down without saying anything aloud. The order in which these various acts are performed remains the same throughout the different aspects of the test. This alone makes it possible to draw any conclusion from the inconstant responses, which are so disconcerting, unless the answers are recorded in this manner. Moreover, this method enables us to learn how the patient responds to the same series of tests put before him in different ways. I have described all these methods of examination in a recent number of *Brain*, and shall not dwell further upon them [13]. The principle upon which they are based is to set a similar task before the patient through various forms of command; these he must execute by different methods. He is no longer asked to speak, to read or to write; but all these methods of expression are used to answer the same series of tests.

As soon as I began to apply these methods of examination to patients suffering from aphasia, it became obvious that none of the ordinary theories bore any relation to the facts I discovered; it was not until I had read through a complete series of Jackson's papers that I recognized the importance of the principles he had enunciated in the light of my own observations.

Shortly after the beginning of the War, patients began to pass into my care with wounds of the head, who suffered from defects of speech slighter and more specialized than any I had seen before. Moreover, these young men were struck down in the full pride of health; many of them were extremely intelligent and anxious to be examined thoroughly. As their wounds healed, they were encouraged and cheered by the obvious improvement in their condition. They were euphoric rather than depressed, and in every way contrasted profoundly with the state of the aphasic patient met with in civilian practice. From this time onwards the work progressed rapidly, and the results that I shall lay before you are based mainly upon these cases of unilateral wounds of the head.

But, before we enter on the positive results of these researches, I am anxious to clear the ground of certain preconceptions. We know

that speech can be affected by destruction of the substance of the brain, but this does not show that "the faculty of speech" is localized in any area of the cortex. We should as soon expect a special centre for eating as for speech; both are complex acts which do not correspond to any specific group of functions. No lesion, however local, can affect speech and speech only. The cerebral injury disturbs certain physiological processes which subserve the complex acts which we speak of as speech. Now, no anatomical lesion corresponds exactly to a single group of physiological functions; the acuteness and severity of the onset is often a more important factor in determining their nature than the extent of the lesion. On the other hand, there is no single psychological function or "faculty" corresponding to speech; any organic injury which produces a disorder of speech disturbs other functions not usually associated with language, or leaves unaffected much that undoubtedly belongs to speech. We must therefore get rid of all those *a priori* conceptions, which underlie such terms as "motor" and "sensory" aphasia, "alexia," "agraphia," or "amnesia verbalis." No disorder of speech due to a unilateral lesion of the brain corresponds exclusively to any one of these categories, still less can these hypothetical conditions be associated with limited destruction of any one part of the brain.

An organic lesion disturbs certain physiological processes which are necessary for the complex acts which underlie the use of language. Words, numbers, pictures, and every function which depends upon the use of these symbols in constructive thought may be affected. Any mental process is liable to suffer which demands for its performance exact comprehension, voluntary recall, and perfect expression of symbolic representations. I have therefore suggested that the various functions disturbed in aphasia and allied conditions might be spoken of as "symbolic thinking and expression," because it is mainly the use of words, numbers and pictures which suffers in these disordered states. But this name must not be taken as in any way defining the group of processes affected; I should have preferred, had it been possible, to have employed some entirely indifferent term. For it is symbols used in a particular manner which suffer in these disorders and not all symbolic representations.

The more nearly the symbolic action approximates to a perfect proposition, the greater difficulty will it present, and the patient will probably fail to execute it correctly. Conversely, the more closely it corresponds to matching two sensory patterns, the less likely is it

to be disturbed. Highly complex symbolic acts suffer more gravely than those of lower propositional value. For example, if a patient seated opposite the observer attempts to imitate a series of movements which consist in touching the eye or ear with one or other hand, he may fail grossly. He can however execute them perfectly when the observer stands behind him and they are reflected in a mirror. For in order to imitate movements sitting face to face he must formulate the various factors which make up the command; whilst to copy them when reflected in a mirror is an act of almost pure imitation. But if, instead of imitating the movements, he is asked to write down what he sees in the mirror, he again fails grossly; for he is now compelled to formulate the task in words, and so fails to describe gestures he can imitate perfectly.

The higher the propositional value of the mental act, the greater difficulty will it present. Thus, the patient may be able to execute a printed command to hold up his hand, although he is unable to carry out an order to touch with it his eye or his ear. The addition of the second factor has rendered the task too difficult. The larger the number of alternatives presented by the order, the more certainly will the desired action be defective. All propositions express an abstract relation; but even the same generalized statement may vary in difficulty according to the means by which it is expressed. For example, during the compass test, the aphasic patient may be entirely unable to record in speech, or in writing, whether he has been touched with one or two points; but if the figures 1 and 2 are written on a sheet of paper, he can indicate correctly whether the contact was single or double. Under the ordinary conditions of this test, he is not only compelled to formulate in words his sensory impressions, but he must express them in verbal symbols; but when it is carried out according to the second method, he has only to determine whether his sensations are of one or two points, and the means of expression lie on the table before him. When the defect consists of want of power to evoke words or names, the patient may be unable to name a set of common objects, although he can choose them correctly to oral or printed command. The verbal symbol conveys its proper meaning when presented ready formed in sound or in print; but to produce it freely at will demands a greater perfection of symbolic thinking and expression. In the same way when an aphasic calls scissors "that is the tweezers to cut with," he is expressing a lower grade of symbolic recognition. One of my patients was unable to name a series of colours placed before him, and could not choose them cor-

rectly to oral or printed commands. But if instead of the names he was allowed to call black, "what you do for the dead"; red, "what the staff wear," with similar descriptive phrases for each of the other colours, he named them all correctly. These metaphorical modes of expression are simpler than names which consist of a single word; for the more concrete is lower in the hierarchy of mental processes than the general and abstract.

Behind every propositional expression lies recognition of the meaning of symbols; I must be able to appreciate the full significance of words, numbers, and pictures before I can pose them in propositional form. This loss of meaning is the cause of many aphasic defects; thus, the short and the long hands of the clock have acquired a significance which converts each one of them into a direct symbol, and they are often confused, or used wrongly in cases of aphasia.

When adding two numbers together, it is easier to reach the answer by counting than by direct proposition. Thus, many aphasics can add 6 and 3 by saying to themselves 6, 7, 8, 9, but cannot formulate $6 + 3 = 9$. For the same reason some of them could set the clock correctly to a command given in railway time, but not if it was expressed in words. Told to set the clock at 4.45, the patient placed the hour hand at 4, and then swept the other round the face to a position he associated with 45 minutes. But asked to set a quarter to five, he placed the one hand at 5, whilst the other hovered uncertainly between a quarter past and a quarter to. This does not depend on a difference in the power of comprehending words and numbers; for when the patient attempted to tell the time it was equally difficult for him to evoke the names "4.45" and "a quarter to five."

Many of the disorders found in aphasic patients are the result of inability to recognize the significance of words and names. If, however, they fail to appreciate with certainty the ultimate meaning in thought, they are liable to become confused over the intention of an action, whether self-suggested or imposed from without. The patient no longer perceives clearly the goal at which he must aim. Thus, a young officer could thread a quadrilateral frame for his bee-hives if the action consisted in bringing the wire across from one side to the other and back again through neighbouring holes, but as soon as he attempted to go from corner to corner, he failed entirely.

Perfect symbolic thinking and expression demand that words, numbers, pictures, and all they stand for in thought should be susceptible of voluntary manipulation. It is this aspect that is usually

affected in the more verbal forms of aphasia and in those that are characterized by the use of jargon; these are not due to "dysarthria," but are produced by defective conceptions of the structure and rhythmic balance of the symbol, which interferes not only with articulated speech but also with internal verbalization. All these functions are not uniformly disturbed in every instance, and aphasics differ profoundly in their clinical manifestations. The majority, especially in the earlier stages, show evidence of widespread defects in the use of language; the more acute and severe the lesion, the graver and more extensive will be the disorder it produces. Many of these changes may disappear, and sometimes the patient recovers entirely; but, in serious cases, one or more aspects of symbolic thinking and expression remain affected over a considerable period, and the aphasic manifestations consequently assume some particular form.

Analysis of these clinical varieties seems to show that the various functions included under the term "symbolic thinking and expression" can be dissociated in different ways under the influence of organic injury. They do not correspond to different stages of dissolution or recovery; nor do they reveal directly the elements out of which language is built up. On the contrary, they show the components into which a highly complex set of psychical processes can be separated by destruction of certain portions of the brain. Provided we bear these principles in mind, we are justified in grouping the clinical manifestations under separate headings. Each case of aphasia is the result of the loss of one or more of these groups of functions; fortunately, all of them are rarely affected in the same patient, for, if this were the case, he would be reduced to a state in which all detailed examination would be impossible. Thus, in each patient we must determine which functions are disturbed and which have remained unaffected. By careful analysis it seems possible to separate these disorders of speech into four main varieties; but it must be remembered that they can appear together in every combination.

To each of the groups I have given the name chosen from the most salient defect in the use of words.

(1) *Verbal aphasia.*—This is essentially a disturbance of word formation; words are evoked with difficulty, the patient's vocabulary is greatly restricted, and enunciation is slow and halting. Writing tends to show the same sort of errors as articulatory speech and spelling is defective. The patient has difficulty in reading to himself with pleasure, because he is unable to retain in his memory a long series of words.

Numerals are affected to a slighter degree; their significance may be recognized and acted on correctly, although they are wrongly enunciated. As speech returns, commands given in spoken or printed words can be executed, but orders which necessitate the evocation of some word or phrase may be carried out badly. These patients recognize, however, whether the task they are attempting has been performed correctly or not. They can draw, play card games, and appreciate jokes set out in print or in pictures. It is this group of defects which is mainly responsible for the condition described by Broca as "aphemia" and usually spoken of as slight "motor aphasia."

(2) *Syntactical aphasia.*—This is an easy form to distinguish because the patient tends to talk jargon; not only is articulation of the word ill-balanced but the rhythm of the phrase is defective, and there is want of grammatical coherence. Speech, once started, is voluble and words are emitted with great rapidity; sometimes each one is comprehensible, however difficult it may be to gather the full meaning of the phrase; but in other cases the words uttered are pure jargon. The power of naming objects placed before him may be retained by the patient, in spite of the jargon by which he is hampered. Not infrequently, when he cannot utter some word, or when the sound emitted is incomprehensible to his auditor, he can write the name correctly. These patients can read if they are not compelled to reproduce the meaning in words; writing is usually less affected than external speech, and single words, especially names in common use, can be written correctly; but any attempt to convey a formulated statement is liable to end in confusion. This form was described by Hughlings Jackson, but has not received the attention it deserves except in the writings of Pick.

(3) *Nominal aphasia.*—This is essentially a defective use of names and want of comprehension of the nominal meaning of words or other symbols. The patient reads with extreme difficulty, especially if he attempts to spell out the words; writing is gravely affected, but he may be able to copy print into cursive handwriting. Writing to dictation and all actions demanding choice are performed with difficulty to spoken command; counting is possible to a varying extent, but the significance of numbers, the power to carry out simple arithmetical operations, and appreciation of the relative value of money are usually more or less affected. The patient is unable in most cases to draw an accurate ground plan of some room with which he is familiar; he cannot play cards, but chess and draughts may be possible. This form cannot be fitted into any of the older methods of classification; for, on the one hand, it has

some of the characters of "motor aphasia," whilst, on the other, other defects would have been attributed to "sensory aphasia." The separation of word-formation from naming and its allied functions is an entirely new feature in the classification of the aphasias.

(4) *Semantic aphasia.*—So far, the names I have applied to the various forms of disorders of speech have borne some relation to the verbal defects; for this group, however, it is difficult to find a suitable designation that will express the essential nature of the disturbance which extends beyond the limits of organized words. I have chosen the term "semantic" as a label for this form of aphasia, because the affection comprises want of recognition of the full significance or intention of words and phrases. The patient may understand each word or short phrase exactly as he can comprehend the details of a picture, but the ultimate meaning escapes him. He fails to grasp the final aim or goal of the action imposed upon him from without; he cannot formulate symbolically a general conception, although he can enumerate the details of which it is composed. He can read and write, but the result tends to be inaccurate and confused; counting is possible and the value of numerals can be recognized, but arithmetical operations are impossible, or are carried out uncertainly and with difficulty. The patient is unable to add or subtract, because the mathematical process itself is incomprehensible. He fails entirely to comprehend most jokes, especially if they demand the complete understanding of a picture or its legend. He cannot play card games or put together puzzles, which confuse him greatly. These semantic disorders interfere seriously with the actions of daily life and render the patient useless for any but the simplest employment; and yet his memory and intelligence may remain on a comparatively high general level. He does not forget people or places, and can recall accurately events, both recent and remote; but he has lost the power of appreciating the ultimate or non-verbal meaning of words and phrases, and fails to recognize the intention or goal of actions imposed upon him.

I have attempted to put before you shortly a conception of the phenomena of aphasia, based on a systematic re-examination of the clinical facts by new methods. The results I have obtained are of no direct practical value to the physician, but they form a fascinating example of the interaction of body and mind—one, moreover, capable of experimental demonstration. This problem has occupied the attention of the acutest human intellects for over two thousand years. The schoolmen answered the eternal riddle in material terms founded on

imaginary anatomy. They were followed by the philosophers, who, for the most part, spun their theories out of *a priori* conceptions. Then came the era of the physicians, who were unwillingly forced to face the question, because the most illuminating examples of the effect of bodily conditions on the state of the mind were entrusted to them for therapeutic supervision. They developed an extensive and accurate acquaintance with the anatomy of the brain, but employed the fruits of this great advance in knowledge in the service of an obsolete and almost mediæval psychology. Fifty years ago Hughlings Jackson raised the question of disorders of speech to a higher plane by rejecting all *a priori* conceptions; but he stood alone and medicine turned a deaf ear to his teaching. To-day, however, the older psychology is tottering to its grave, and I am proud to think that a long continued and arduous series of researches has led me at last to understand that great empiric philosopher, the founder of English neurology.

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Proceedings of the Section of Neurology of the Royal Society of Medicine.

President—Dr. Ernest S. Reynolds.

Meeting held November 11, 1920.

Discussion on Aphasia.

Dr. Henry Head, F.R.S., said that (1) it was universally acknowledged that speech could be affected by destruction of the substance of the brain. If the lesion was acute, all aspects of the act of speech might be generally reduced. As the nervous tissue recovered, all these functions might return more or less together, and the aphasia disappeared without the manifestations assuming at any time a specific form. This generalized loss of function was particularly liable to occur when the disorder of speech was produced by vascular lesions or by any condition that lowered the vital activity of the brain. In cases of head wounds it was therefore important to wait until the original nerve shock had passed away and the wound had healed, before attempting to draw any conclusions as to the supposed specific character of the loss of speech. It might happen, however, after the acute stage has passed away, that the lesion of the brain was found to have affected the production of those physiological activities which underlay one or more special aspects of the perfect use of language and allied functions. Speech consequently assumed in such cases a clinically specific form.

(2) The categories of such partial forms of aphasia could only be drawn up in terms of the tests employed; they did not correspond to exclusive loss of speaking, reading or writing, nor could they be divided into "motor" or "sensory" abnormalities. As the result of serial tests, he had attempted to show that no descriptive term can be found which covered all the functions disturbed in one or other forms of aphasia and kindred disorders of speech. For amongst these functions were many which were not usually associated with speech. He had

therefore adopted the name "Symbolic Thinking and Expression," because it represented that group of psychical activities which was most severely affected by unilateral lesions of the brain. Analysis of the clinical varieties of aphasia seemed to show that the various functions included under this term could be dissociated in different ways under the influence of organic injury. They did not correspond to different stages of dissolution or recovery: nor did they reveal directly the elements out of which language was built up. On the contrary they showed the components into which a highly complex set of psychical processes could be separated by destruction of certain portions of the brain. Something was lost which made perfect speech impossible, and the whole act assumed an abnormal form. Part of the manifestations were due to the negative aspect of the disturbance, part to the disorderly activity of function which remained.

(3) Before attempting to determine what portion of the brain when injured was associated with the different clinical affections of speech, it was necessary to discover by serial observations the nature of the psychical disturbance in each particular case. In the past attempts had been made to localize the anatomical site of the lesions responsible for "motor" or "sensory aphasia, "alexia" or "agraphia." But these *a priori* terms did not correspond to any specific functional categories discoverable in cases of these disorders of language due to a unilateral lesion of the brain. The fact that specific clinical forms of aphasia occurred showed that some lesions affected one aspect of the language mechanism more than another. He was prepared to enter on this question later, but was anxious that the present debate should be concerned with the nature of the loss of function produced by a unilateral lesion of the brain and with the clinical forms it might assume.

Dr. JAMES COLLIER: In opening this discussion upon the subject of "Aphasia," I must in the first place thank Dr. Head for the opportunity which he has afforded us and for his kindness in asking me to address you first. There has been for many years a growing revolution against the former conceptions of the nature of the speech function and the explanation of its defects, which has led to much bitter controversy, and has culminated in Dr. Head's bold endeavour to place this subject upon a sounder and truer foundation. It is very important in my opinion that we should have this opportunity of discussing this subject with him, and in this discussion there is no obligation that we should be restricted to the subject matter of his recent publications.

The necessity for this revolution was great. The literature is enormous and bewildering, and the types of aphasia multitudinous. Take for example Lichtheim's seven types based upon a conception of centres of localized function connected by isolated paths which only exist in theory, and with which types our clinical cases never truly correspond. Dr. Head would make a clean sweep of former conceptions and types of aphasia and introduce a newer conception of the functions of the cortex of the brain in speech, a more refined method of observation and a new classification. For the greater part I am in agreement with him. In some details I differ from him, while in others I am not in the position to express an opinion.

We have to bear in mind in dealing with the function of speech and its defects that we are considering the most highly evolved and complicated function of the brain, closely bound up with intellect itself, the mode of working of which is probably beyond any flights of human conception. And any analysis which we can make into this function must be of necessity crude and liable to misunderstanding. Conceptions of the coarse localization of function in the physiological substratum must, it seems to me, be erroneous, and any attempts to formulate the working of this intricate mechanism in diagram are fundamentally absurd.

I shall direct your discussion therefore to:—

(1) Your views upon the matter of localization.

(2) Your opinions as to the utility of retaining any of the time-honoured terminology.

(3) Would you retain any of the types of aphasia as true clinical types?

(4) Your views upon Dr. Head's method of examination and upon his classification.

The former conceptions of aphasia were based upon the most able clinical and pathological investigation of great men. They have served to teach us, and, so far as the localization of gross cerebral disease is concerned, they have led us to almost as great an accuracy in the regional diagnosis of local disease as we are ever likely to reach.

It is interesting to consider for the moment what were the grounds upon which the conceptions of isolated centres concerned with the registration of visual word images, auditory word images, and executive speech function were built up. It was from the study of comparatively large anatomical lesions, always subcortical as well as cortical, and generally more subcortical than cortical, and when such lesions were

situated in such a position upon the confines of the cortical speech region as to sever more or less completely the usual paths of inlet to the speech region, either upon the visual side or upon the auditory side, or blocked the paths of exit upon the executive side, the most obvious of the speech defects resulting were failure of acceptance of speech on the visual side, word-blindness, or on the auditory side, word-deafness or failure of exteriorization of speech—motor aphasia and agraphia.

It followed that these limited regions—the angular gyrus, the mid-temporal region, and the third and second frontal convolutions—were labelled as visual word-centre, auditory word centre, and motor speech centre. I submit therefore for your discussion that when the conditions which have been termed "word-blindness," "word-deafness," "motor-aphasia," and "agraphia" occur, any one of them, as the most obvious result of a lesion of the brain, that they are the result of isolation of the speech region of the cortex upon the incoming sides and upon the outgoing sides respectively, and are not due to the destruction of local memory centres. It follows from the nature of the lesions that when these incoming and outgoing paths are damaged, there is often considerable damage to the cortex itself with the appearance of speech defects of a different order. Dr. Head would rid us of these terms, "word-blindness," "word-deafness," and "motor aphasia." Yet they are the terms which have been long in use, and while freely admitting that they may be fundamentally incorrect, physiologically inadequate and usually untrue clinically, yet these terms do roughly describe the most obvious features of many speech defects. They have proved useful for teaching purposes and will prove hard to replace.

In the Hughlings Jackson lecture Dr. Head doubts whether there are any such conditions as "pure alexia," "pure aphasia," and "pure agraphia," and in this attitude I am unable to follow him. For whatever conception we may have of the localization of function in the cortical speech region, we are bound to admit the existence of afferent paths to the speech region upon the auditory side and upon the visual side, and efferent paths therefrom by which speech is usually exteriorized, both spoken and written, and in these paths there is surely strict anatomical and physiological separation. In so far as these paths exist as definite anatomical tracts for a sufficient distance to allow of the isolated involvement of any one of them by a lesion, we cannot deny the possibility of such a lesion, nor that the resulting speech defect is more or less narrowly confined to one aspect of speech.

I hold that the clinical condition described by Dejerine as "pure alexia" or "pure word-blindness" and attributed to a lesion at the posterior limit of the speech area, which severs the connection of that area from the visual area, is one of the most certain and definite of clinical conditions. I have seen it many times and have seen the theoretical lesion verified on more than one occasion.

Similarly I see no reason why the conditions of pure agraphia and pure aphasia also described by Dejerine should not be true clinical conditions. Their acceptance does not affect our conceptions of the cortical functions of speech. There must be both physiological and anatomical separation on the way out of the paths by which spoken and written speech is exteriorized, and the possibility of isolated damage to such paths must be admitted to be possible. I have seen one case which during the early moments of his seizure was certainly a case of "pure agraphia." This was a man who was lying in the National Hospital with a fracture-dislocation of the back, who in the course of writing a letter to his wife was seized with a disability to write, to which he immediately had my attention called, and for the space of more than an hour, during which time his condition was investigated by myself and by Dr. Rennie, now of Sydney, he presented a defect which exactly corresponded to "pure agraphia." After which his lesion extended widely, and proved rapidly fatal. We found in this case a subcortical lesion beneath the lower frontal convolutions associated with an extensive thrombosis of the Sylvian artery, and I think it is not too much to claim that the commencement of the subcortical lesion was in such a position as to block the outgoing path for written speech, and did actually produce a condition of "pure agraphia." I agree that pure "word-deafness" does not exist as a clinical entity, and I would explain this fact in that it is unlikely for any lesion to sever the auditory path entering the speech region of the cortex without interfering grossly with that cortex both anatomically and physiologically. Yet there are cases which all of us must have seen in which lack of acceptance of spoken speech stands out in undue contrast with the acceptance of visual speech, and I would attribute this isolation of function not to any separate location of function in the speech cortex, but to blocking of the auditory afferents.

I presume that the chief paths entering the cortical speech region do not end abruptly, nor do the outgoing paths begin abruptly, but rather gather in their course, and that therefore the element of blocking must be an important factor in the production of the speech defects under consideration.

There is another consideration in connection with the afferent paths which I deem of great importance, especially in connection with those speech defects which Dr. Head terms "syntactical." When we speak aloud we have an immediate recognition of what we say by means of the auditory path, which allows of analysis of the correctness and fitness of what we have said and of its correction if faulty. This backlash, if I may be allowed the expression, is of great importance during the learning of speech in any form, and it surely must be a great factor when we speak, in keeping the physiological activity of speech and thought at a high level.

There is also another backlash in the way of the sensations accompanying the movements of the executive mechanism, but this plays but a very minor part in the speech of normal persons, though since in the deaf-mute who has learned to speak by lip reading it is his only guidance both in the learning of his speech and in its execution, this factor must not be forgotten.

There is of course a similar constant visual appreciation and correction in writing.

Now, when on account of the lack of acceptance of spoken speech this immediate consciousness of the correct execution of speech fails, surely this must throw the mechanism of thought and speech into dire confusion. I submit that this is the essential cause of those defects of speech which Dr. Head groups as "syntactical," and certainly of such conditions as voluble jargon-aphasia. I shall refer to this subject again later on.

Dr. Head in his Linacre Lecture seems to favour some vague separation of function, some very general localization of functions in the cortical speech area which he does further comment upon. If by this he means a gradual passing over from behind forwards from receptive functions to executive functions, I am inclined to agree with him. I take it that he would expect "verbal defects" from lesions farther forward than those productive of "nominal" and "semantic" defects. If on the other hand he means any separation of localization for visual and auditory speech functions, then I disagree.

It seems to me that the function of visual speech, acquired at a much later age than is auditory speech, tacked on as it were to an already perfect and deeply impressed function of auditory speech, learnt by means of an already well versed auditory speech function, must occupy the same physiological substratum as does the auditory speech function, and is separately localized only in so far as its chief afferent and executive paths are concerned.

I submit for your discussion, that, as the result of lesions of the cortical speech region in any of its parts, there is likely to be depression of its physiological activity as a whole, and that the expression of this depression may be a major impairment or loss of its less deeply impressed functions. For the speech functions are not equally impressed nor equally stable. The auditory speech functions both upon the receptive and upon the expressive side are in most people much more deeply impressed and more stable than are the corresponding visual speech functions. And I submit that this accounts for the impairment of loss of visual speech recognition which almost always occurs in lesions of the anterior regions of the speech cortex, and that it accounts also for the major loss of the visual speech functions which is the rule in lesions situated farther back.

I have in two cases observed the practically complete recovery from aphasia in polyglots who were afflicted with syphilitic vascular disease of the speech region, and in each case recovery was much more rapid in the more deeply impressed native tongue, and less rapid and less perfect in the language more recently acquired, and less long used. And when speech was practically recovered so far as the native tongue was concerned they still presented gross defects in the foreign tongue. It would be fair to say that at a certain stage of recovery they were aphasic in one language and not in another, and this must surely be explained by the dropping out of the less impressed function when the activity of the speech functions is lowered, as the result of disease.

Dr. Head calls particular attention to the highly important and certainly correct principle that the alterations in speech function which result from lesions of the brain are not in terms of the primary elements out of which speech has been evolved, nor do they reveal the elementary basis of the acts of speaking, reading and writing, but that they are in terms of the complete and highly developed function, which fails progressively from its highest to its lowest with increasing degrees of damage.

Though in infancy we learn our speech in terms of words and short phrases, and our writing in terms of letters and words, yet when speech is highly developed we speak and receive speech in a running pattern of sounds of which the individual elements are disregarded. We do not in reality speak, hear, read or write in words, but in a running pattern comparable and often inseparable from the running patterns of thought. It is the pattern which is exteriorized and accepted as a whole. The individual words of which this pattern is made up

singly convey little or nothing of meaning unless we put them into another pattern by parsing them. The running patterns of speech are of great importance in the consideration of speech defects. In their course they reinforce and raise the level of activity of speech and thought, and they have an important momentum. The common example of the aphasic who is unable to use a particular word on command, and yet produces it without effort in the run of the pattern by which he is expressing his inability, or trying to talk round the subject, well illustrates this point. In setting a speech pattern going he gets a run at his difficulty just as in taking a running jump one gathers the necessary momentum to overcome the difficulty. Deformity and distortion of these patterns are common phenomena among speech defects, and the difficulty to set them in orderly running is fundamental.

Sometimes one is surprised in examining a case in which speech acceptance is seriously impaired, to find that the patient will gather considerable meaning from a phrase when he does not do so from simpler forms of approach. He accepts something from the pattern when simpler forms of communication do not appeal to him.

Dr. Head has laid before us in the Linacre Lecture a scheme for the examination of patients suffering from defects of speech which seems to me in every way admirable and worthy of universal adoption. It provides for the examination of the speech functions in the varying states of their incapacity from the lowest to the highest. The serial tests are calculated to rouse into activity depressed functions which otherwise give no sign of their existence, as for example the patient who though unacceptive to visual speech in any ordinary way matched a colour with its printed name, thereby showing that some dim function of visual speech was rousable by the combined presentation of the colour and its name. Of especial interest as arising from the serial tests is the proposition that inasmuch as an act requires verbalization for the clear recognition of its nature, the act tends to fail in execution if verbalization is defective. This proposition emphasizes the importance of verbalization in the concept. It is so far as I am aware a new proposition—at any rate it is new to me and seems to me to be of far-reaching importance in the interpretation of speech defects.

The serial tests are excellent, the difficulty comes with the interpretation of the results. The classification of speech defects into "verbal" defects, "nominal" defects, "syntactical" defects and "semantic" defects requires careful consideration. Dr. Head's position is clearly

defined. He starts with the conception of a region of the cerebral cortex concerned with speech functions which habitually acts as a whole and not in terms of isolated localized functions. This position seems to me correct and unassailable. He makes an analysis from the clinical side only and commits himself to no opinions of anatomy and localization, but deals entirely with objective physiological defects in his attempt to elucidate the manner in which the speech function breaks up as the result of lesions of the brain. Whatever views we may hold individually upon the nature of the speech functions, such an analysis is not controversial. It can offend no one. It certainly is very valuable. It rests upon a sound scientific basis. In making this analysis he used specially picked cases. Selected firstly because of slight and partial lesions which leave a great part of the anatomical substratum of speech in a relatively physiological condition, and therefore are much more suited for analysis in that they yield much more information. Selected secondly because from the nature of the lesion the cortex of the brain may be deemed to have been particularly affected, though this selection may give rise to doubt as to whether the lesion in any given case was mainly cortical; it is open perhaps to less objection in this respect than are the vascular and other gross lesions in civilian cases upon which great theories have been built up. And lastly selected because they were suitable for the analysis—all cases are excluded in which images are lost. Such an arbitrary selection must be allowed if we are to get a clear issue and avoid confusion. The results of the analysis are recorded in minute detail. There is no attempt at explanation, and no theory is raised upon them. Localization is not considered as this is an anatomical matter. The results are in the present state of our knowledge useful in enumeration only. The classification is a list of symptoms which from their nature tend to fall into four groups, and the patients tend to fall into four corresponding groups.

Dr. Head submits that these groups are the expression of the manner in which the speech function breaks up as the result of the slighter degrees of damage to the cortical substratum subserving that function. Dr. Head's position does not admit of much contention or controversy. It does not in any way subvert or undermine the correctness of the rough methods by which all of us are accustomed to localize gross cerebral disease with accuracy when the speech region of the cortex is involved. It strikes fundamentally at former theories both of the nature of the speech function, and at the localization of separated functions—not many of which I submit have been truly applicable to clinical conditions nor theoretically satisfactory.

Comments upon his division of symptoms and his classification of cases into the four groups cannot be adequately made until we have applied the serial tests to our suitable cases and made our own deductions therefrom in the light of this classification. Whether this grouping does really represent the manner in which the cortical speech function may disintegrate is to me uncertain, for by no method of introspective analysis, no consideration of the development of speech functions, and by no anatomical or physiological considerations can I see why it should do so.

I shall conclude these remarks in referring to two points in connection with his classification which I deem of considerable importance. In connection with verbal aphasia it is quite refreshing to see it laid down with emphasis that deformity of words in the way of mispronunciation, omission and misplacement of syllables—abnormal word formation, in fact—is characteristic of this condition, and further that the same deformity that occurs in the spoken words is met with also in the written words, proving the inseparability of these two functions. This is a clinical fact which has been neglected or passed over by so many writers upon aphasia. Sometimes this deformity is so great as to make the speech almost irrecognizable and in a way a jargon-aphasia. I have been in the habit in the past of referring to this condition as "anterior" jargon-aphasia from the forward situation of the lesion which is usually responsible for its production. It is of course instantly distinguishable from true jargon-aphasia. I am not sure that the essential rhythm of word and of phrase in this condition is always intact as Dr. Head thinks. I believe that considerable defect of rhythm may occur and that the phrase may be deformed as a whole just as the word is deformed.

In syntactical aphasia as a result of damage to the speech region of the cortex, I find myself for the first time in the course of these remarks quite opposed to Dr. Head; it is his meaning that such a condition can arise from a lesion of the cortex. True jargon-aphasia is a thing quite of itself. It is the only condition among speech defects in which overaction is manifest. The volubility which is characteristic of this condition is extraordinary and seems to increase the more severe the jargoning of the speech becomes. Even from the first there may not be that general depression and difficulty of arousing the speech functions that is seen in connection with other forms of speech defect. The intelligence and quickness of apprehension of all uncomplicated cases of jargon-aphasia even in its severest degrees stand out. The condition seems to

me that of a function severed from control and without guidance. I must admit that I have not had the opportunity of examining cases with such mild degrees of this condition as has Dr. Head. I have never in any case of this nature seen so great a degree of speech acceptance upon the auditory side as some of his cases had. In all my cases there has been severe blocking upon the auditory side.

I may here refer to two cases almost identical in nature which were under my observation and which were of so striking a nature as perhaps to have biased me unduly in my conception as to the nature of jargon-aphasia. These were both men who at their work were seized with a slowly oncoming jargon-aphasia which in the course of a few hours rendered speech incomprehensible. There was no ictus with the onset, no affection of intelligence, and these men did not even stop their work. They were brought to me within a few days—the one by the police for making a disturbance in the street, the other by his wife, as being mad. They were both uncomplicated cases of severe jargon-aphasia. The one was absolutely non-acceptive of speech either upon the auditory or upon the visual side, and the other was non-acceptive upon the auditory side, but appreciated visual speech to a considerable extent. One of these patients presented optic neuritis, and the other soon developed it. Both of the cases showed on pathological examination a well-defined tumour undercutting the posterior and mesial aspects of the temporal lobe, comparatively far from the cortex which was nowhere involved. The tumours were in such a position as might reasonably be expected to sever the auditory afferent path to the speech region in both cases, and in the first case the tumour curved round towards the cortex in the angular region, and is likely to have severed the visual afferents.

The striking points about these two cases were :—

The onset of jargon-aphasia as the initial symptom.

Its rapid development to an extreme degree.

The lack of acceptance of auditory speech.

The peculiar subcortical position and discrete nature of the lesions which nowhere involved the cortex.

It was difficult to regard these cases in any other light than that of isolation phenomena in which the auditory balance and rhythm which is so essential a part in the production of speech was lost owing to the interruption of afferent paths to the speech region of the cortex, by which speech exteriorization is habitually guided. I submit that it is the lack of the immediate impressions of correct execution which we

receive when we speak, both with our ears and from the muscular movements of speech, which is responsible for the condition of jargon-aphasia. It is the expression of a function which has lost control and which has "gone mad" from isolation.

Surely these cases of jargon-aphasia are primarily unaware of their defect of utterance by reason of lack of auditory acceptance, some of them partially perhaps, but the majority of them deeply. They do not show the embarrassment and loss of confidence that such defects, if recognized, would certainly cause, though they may show some embarrassment and emotion from lack of appreciation of what they are trying to say in their audience. It is true that in one of Dr. Head's cases there was a greater degree of auditory acceptance than I have ever seen in a case of jargon-aphasia, but I gather that all of them were more or less defective in this way, but to what degree he does not make very clear.

Visual speech and writing are almost always affected to a less degree than auditory speech in cases of jargon-aphasia, and this I attribute to preservation of the visual afferents. One of Dr. Head's cases seems to show that correct writing can occur without verbalization—I refer to the case who on being shown a matchbox uttered a three-syllable jargon and promptly wrote the word matches correctly. This is a very interesting and unusual fact, for writing is usually strictly dependent upon verbalization, and when verbalization is imperfect the writing shows exactly the same defects as does speech. I agree with Dr. Head that verbalization is always very imperfect, and in the more severe degrees of the condition writing is almost as much affected. Now, this relative escape of the visual word function is surely the reverse of what occurs in cortical lesions, in which, I believe, the visual word function always shows a major defect compared with that of the auditory word function, and I use this as an argument against the cortical origin of jargon-aphasia.

Further, jargon-aphasia is a comparatively rare condition. It is hardly ever met with in the common lesions of the temporal region from vascular disease of the Sylvian artery where the temporal cortex is likely to be involved. I think also that when jargon-aphasia is due to a progressive lesion, an extension of the lesion to the temporal cortex causes the jargon-aphasia to lessen in volubility and finally to disappear.

I submit that an intact cortex is necessary for the appearance of this form of speech defect, and that it is a pure type of aphasia, and like the other pure types of aphasia is referable to an isolation from auditory afferents and to a subcortical lesion.

SIR JAMES PURVES STEWART: We are so accustomed to receive original and stimulating thoughts from Dr. Head that whenever he brings us something fresh many of us tend to be prejudiced in advance in his favour. This, of course, being a mere feeling-tone, partly thalamic, and not a process of cortical reasoning, is just as wrong as it would be if we were to start prejudiced against him.

At the outset let me say that Dr. Head's conception of aphasia is full of instruction to us all. No one will venture to cast any doubts on Dr. Head's clinical observations. Every one of us must be grateful for the new scheme of investigation which he has presented to us and for the various interesting clinical facts which this scheme has brought out. We have studied with interest his proposed new classification of aphasia into four varieties, viz.:—

(1) Verbal aphasia. Defective word-formation, both in internal and external speech.

(2) Nominal aphasia. Defective use of nouns, both spoken and written.

(3) Syntactical aphasia, with want of coherence and a tendency to talk jargon.

(4) Semantic aphasia. Deficient comprehension of the full significance of words and phrases. Although the patient can speak and write, he cannot formulate a general conception but only the details of which it is composed.

This new classification is of the highest psychological value. But there seems to me no adequate reason why we should necessarily throw overboard all our previous clinical experiences, or our division of aphasia into two great classes, viz.:—

(1) *Psycho-motor aphasia*, aphasia of expression, or verbal apraxia.

(2) *Psycho-sensory aphasia*, aphasia of comprehension, or verbal agnosia.

More especially as these two great clinical divisions correspond to well-established anatomical facts.

One thing we note in Dr. Head's recent paper is that he abstains, so far, from giving us particulars of the anatomical site of the brain-lesion in a single one of his cases.

May I be allowed, as an ordinary clinician, to relate a few clinical examples of aphasia. All except one have been selected, like Dr. Head's cases, from young men suffering from war-lesions of the brain.

Case 1.—W. M., aged 55. Lower frontal lesion.

This patient was admitted to the Westminster Hospital with signs of acute cardiac failure due to old aortic disease. He had no paralysis of the face or

limbs and was able to speak fluently. His pulse was almost imperceptible and the heart sounds were almost inaudible, forty-eight per minute.

Twenty minutes after his admission to the ward, he suddenly became speechless and his face became asymmetrical. His intelligence was unimpaired. He was able to understand and execute all sorts of verbal commands, to put out his tongue, to place his hand on any part of his face or head, to move the right or left thumb by bending it half-way or straightening it out, as requested. But he was unable to utter any word whatever. The right face was weaker than the left. There was no weakness of any limb, but the right plantar reflex was extensor in type and the right abdominal reflex was absent.

Two days after admission he died, with symptoms of increasing cardiac weakness, cyanosis and rhythmic breathing of stertorous type.

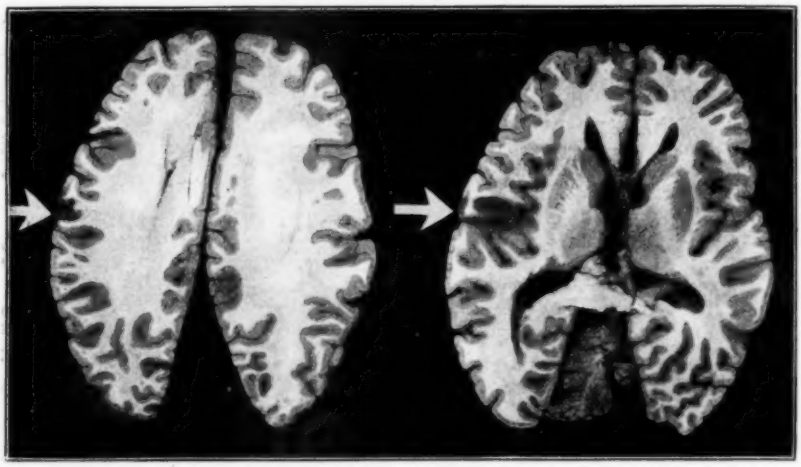

FIG. 1.—Left lower pre-central lesion.

At the autopsy, there was an old syphilitic aortitis, and just above the aortic valves was a large tag of thrombus about an inch long and one-eighth inch thick.

The brain, after hardening, showed a small area in the lower third of the left precentral gyrus, in which there was a dark marbled appearance, due to embolic blocking of a small cortical arteriole (see fig. 1). This lesion extended deeply into the operculum, but did not affect the insula, nor the basal ganglia, i.e., Marie's "lenticular zone" was unaffected. There was no other lesion elsewhere in the brain.

This is an uncomplicated case of psycho-motor aphasia. Probably Dr. Head would classify it as a verbal aphasia.

Case 2.—W. T., lieutenant, aged 24. Mid-Rolandic lesion, pre- and post-central.

The patient was wounded by a ricochet bullet in the left parietal region. He was knocked down, but not unconscious. His speech at once became jumbled. After a quarter of an hour he noticed paralysis of the right arm, and after about four hours the right leg also became paralysed.

A week later he was trephined, and two pieces of bullet were removed from the surface of the dura. The dura was not opened.

The patient states that after his injury he could not get out his words at all, nor could he understand things properly.

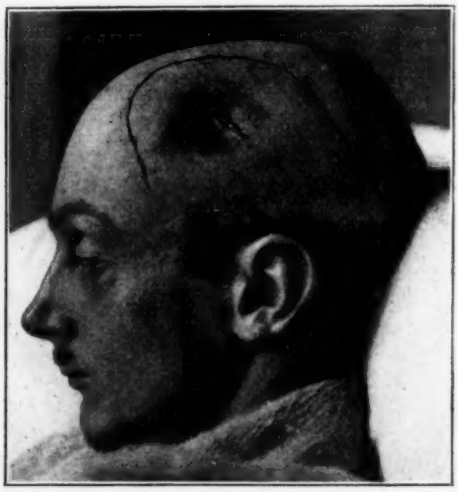

FIG. 2.—Left pre- and post-central wound.

On examination, five weeks after the original injury, he was highly intelligent and had no evidence of word-deafness or word-blindness. He understood and executed accurately verbal requests and also written requests, e.g., "Close your eyes and then put out your tongue."

He was able to write spontaneously and to dictation short sentences with his left hand, copying accurately, but occasionally making mistakes in spelling to dictation, e.g., "hopsital" for "hospital."

He recognized all objects shown to him and named them correctly, but tended to miss out the initial consonant, e.g., "'overeign, 'illing, 'atch-box." But he repeated words and phrases correctly to dictation. He added up columns of figures fairly accurately and read the newspapers intelligently.

The right face was slightly weaker than the left. There was severe paralysis and spasticity of the right upper limb and slight weakness of the

right foot. There was astereognosis of the right hand and foot. With the right hand he recognized an object like a coin as hard and round, but could not name it. The deep reflexes were increased in the right upper and lower limbs, with right-sided ankle-clonus. The right plantar reflex was extensor in type and the right abdominal reflex absent.

A month later he had improved a great deal. He now only hesitated very slightly, chiefly with initial sounds. Sometimes he misplaced syllables, but chiefly when excited. He felt himself mentally brighter, but thought he was a little slower than before his injury, e.g., when counting money.

He understood everything said to him, and executed accurately written commands. He copied accurately from printed to written letters and wrote to dictation (left hand) without making spelling mistakes. He added up figures, both simple figures and £ s. d., e.g.,

£2	17	9
8	13	4
£11	11	1

He repeated words dictated to him, but sometimes mispronounced syllables, e.g., said "February twenty-fith." He named objects shown to him accurately, also read aloud accurately from a book.

The weakness and astereognosis of the right upper limb were still severe, but he was now able to walk, dragging the right leg.

We clinicians would call this an example of psycho-motor aphasia. Dr. Head would probably classify it as a verbal aphasia.

Case 3.—D. M., aged 31. Inferior frontal lesion.

This patient was seen at Salonika. Eight days before I saw him he was admitted to hospital unable to speak, but able to understand what was said to him and able to write with his right hand, jumbling his words in writing.

He had a depressed fracture of the skull in the left upper temporal region (see fig. 3) over the region of the lower end of the Sylvian fissure, apparently from a glancing shrapnel wound. There was a large lacerated scalp wound, and the fracture was found to have fissures radiating backwards for a short distance. The depressed piece of bone was removed by trephining. The dura was intact and pulsated normally. It was not incised. This operation was performed four days after his original wound.

A week after the operation his temperature was normal; there was weakness of the right face with deviation of the tongue to the right side. There was no weakness or anæsthesia of the upper or lower limbs. The knee-jerks and ankle-jerks were brisk and equal; the plantar reflexes were both flexor in type and the abdominal reflexes were normal on both sides.

He had no word-deafness nor word-blindness. He understood and executed verbal requests smartly, also a written order to put out his tongue.

He spoke with some difficulty. When asked his name he said: "Duncan M-M-M-M-enzies." He could not name a postcard, a pin, or a safety-pin. He called a fork a knife, but at once recognized his mistake, and when shown different objects, including a knife, fork, and spoon, and asked: "Is that a

knife?" always said "Yes" when the correct object was indicated, and "No" when it was not so. He wrote a postcard to his parents, writing their address correctly, but repeating several words. His message ran: "I am getting only, only, yours, Duncan."

FIG. 3.—Left inferior frontal wound.

A week later he spoke better, but slower than normally, occasionally confusing his syllables. He called a coin a "Greek fenny," and a safety-pin a "sapety-pin."

A week later he no longer jumbled his syllables, and, save for a certain amount of slowness, his speech was normal and fluent.

This again is a fairly straightforward case of psycho-motor aphasia. Dr. Head might call it verbal aphasia or nominal aphasia, or both.

Case 4.—W. Y., aged 19. Temporal lesion.

He came into hospital without any available history, but he had probably been wounded four or five days previously at Gallipoli and brought straight to Malta, where I happened to see him.

There was a superficial entry-wound three inches vertically above the tip of the left pinna and an exit-wound half an inch above the posterior end of the left zygoma (fig. 4). The cranium was not fractured, and X-rays showed no abnormality.

He had no weakness or anæsthesia of the face, trunk or limbs. The reflexes, deep and superficial, were normal and equal on the two sides. There was no limitation of the visual fields.

He understood and executed simple verbal requests, but very easily became confused, e.g., when told to place his right hand on his left ear. He read aloud slowly and accurately, but did not understand what he read, nor did he

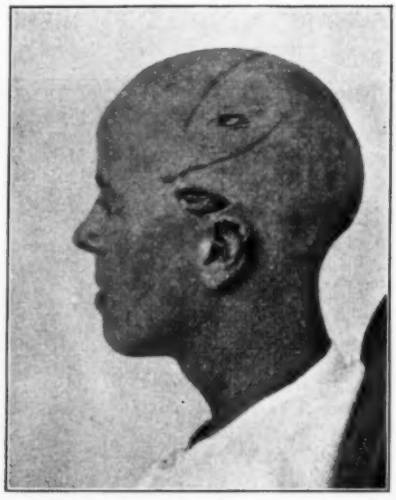

FIG. 4.—Left temporal wound.

make any attempt to execute written requests which he read aloud. When shown the statement $\frac{2}{\frac{2}{5}}$, however, he said, "That's wrong."

He spoke slowly and with difficulty, but could name objects shown to him. When speaking he occasionally jumbled up syllables.

This is a case of psycho-sensory aphasia, with word-deafness, paraphasia and word-blindness. Dr. Head would probably call it a combination of nominal and semantic aphasia.

Case 5.—C. E., captain, aged 22. Temporo-occipital lesion.

Patient had a penetrating wound by a shrapnel bullet. The entry was above and behind left ear, over the posterior end of the first temporal gyrus (see fig. 5). There was no exit-wound and an X-ray showed the bullet lodged ½ in. to the left of the middle line, just above the occipital protuberance, i.e., near the tip of the occipital lobe.

Four days after his injury he developed meningitic symptoms with general epileptiform fits. The wound was laid open and several pieces of in-driven bone were removed from the brain. The fits subsided a fortnight after his injury.

When examined three weeks after the injury, he had a voracious appetite, possibly attributable to his temporal lesion. The wound was soundly healed.

Five weeks after his injury he had no weakness of face or limbs, no anæsthesia, normal deep and superficial reflexes, but a right upper quadrantic hemianopia in both visual fields, due to lesion of the lower lip of the left calcarine cortex.

FIG. 5.—Left temporal wound, with bullet in left occipital lobe.

He understood and executed simple verbal requests, but had difficulty in executing complex requests, e.g., to place the right middle finger on the left ear. He executed written requests, wrote fluently, but occasionally made spelling mistakes, e.g., mis-spelt "Malta" as "Matla." He copied accurately from printed to written letters.

In speaking he had slight hesitation in naming objects but ultimately succeeded. He stumbled over syllables in words like "Gallipoli peninsula." He spoke fluently as a rule.

Here again the aphasia was of psycho-sensory type, with slight word-deafness and paraphasia, or mal-construction of words. Dr. Head would probably regard it as a case of generalized loss, not belonging to any one category.

Case 6.—J. C., aged 25. Temporo-parietal lesion.

Patient was admitted to hospital without any history, but with a recent operation-wound, apparently about a week old, on the left side of the head, including a trephine gap 2½ in. above and 1 in. behind the left external

auditory meatus (see fig. 6). There were also an entry and an exit-wound, one at the left parietal eminence, the other just below the centre of the left zygoma. Which was which, we could not decide.

He had no weakness of the upper or lower limbs; there was doubtful paresis of the right side of the face. He had no hemianopia on rough test and no cutaneous anæsthesia or analgesia. The knee-jerks and ankle-jerks were normal. The right plantar reflex was extensor; the abdominal reflexes were brisk and equal.

He had considerable difficulty in understanding and carrying out even simple verbal requests. When shown written commands he spelt out the letters correctly but made no attempt to carry out the instructions. He

FIG. 6.—Left zygomatico-parietal wound.

wrote with a pencil, writing his name spontaneously and copying from printed to written letters. When shown the statement $\frac{2}{5}$ he did not recognize anything wrong.

He could not repeat words dictated to him nor could he write to dictation even simple words like "hospital."

When shown scissors, he could not name them, but said, "I know what they are for," and made scissor-movements with his fingers. With a pencil, he said, "I know what it is," but could not name it.

A week later the word-deafness was less marked. He could not write to dictation but made mistakes in spelling, e.g., "arterly" for "artillery." He could repeat words dictated to him but could not name objects, such as scissors or a pencil, saying, "I don't know the name of it, I forget."

This case would probably be regarded by Dr. Head as being of the "nominal" variety. But on clinical and anatomical grounds it is a straightforward case of psycho-sensory aphasia.

I might have quoted many other cases of more profound aphasia, due to widespread lesions, but the cases which I have related have been selected because of the relative simplicity of the brain-lesion in each case.

We find then, in cases of psycho-motor aphasia, or aphasia of expression, a lesion in the anterior or psycho-motor area of the brain, whereas in psycho-sensory aphasia, or aphasia of comprehension, the lesion is situated in the psycho-sensory speech areas, whether psycho-auditory or psycho-visual. In both classes of case there is always a certain amount of intellectual disturbance, the equilibrium of the speech areas being rendered less secure, just as a table becomes unsteady, whether one of its anterior or its posterior legs happens to be broken.

We are familiar with Pierre Marie's view that all aphasia is merely an intellectual deficiency, due to disintegration of some part of Wernicke's zone. He claims that the essential fact of aphasia, of whatever variety, is insufficient comprehension of speech. We also know that Marie discards a special motor centre for speech and denies to Broca's convolution any special rôle in the function of speech, except in so far as it contains motor centres for the lips, tongue and larynx. He explains motor aphasia as mere intellectual deficiency *plus* anarthria, and refers this anarthria to a lesion of the lenticular zone (comprising the lenticular nucleus and its surrounding white matter).

But motor aphasia is not a mere paralysis of the lips or tongue; it is a true apraxia, due to amnesia of the movements of articulation. Moreover, if articulative difficulty were the cause of the speech loss, it ought to render the articulation of all words difficult. Now we know that most aphasics, however profoundly speechless, are not wordless. They usually have a "recurrent utterance" of some sort, and this recurrent utterance is articulated perfectly clearly.

It would, therefore, seem that the psycho-visual, psycho-auditory and psycho-motor speech centres do exist, and that lesions of these centres, disrupting the cerebral mechanism of speech, are the cause of our well-defined clinical types of aphasia.

Dr. Head by a series of ingenious and elaborate tests has arrived at a new, useful and philosophical basis of classifying aphasias. But this

does not necessarily mean that other classifications may not also be correct. Just as one observer may classify a crowd of people into men, women and children; whereas another may classify them into Englishmen, Scotsmen, Irishmen, Welshmen and foreigners; or another again into soldiers and civilians. It all depends on the angle from which the facts are viewed. Dr. Head has opened a new window into the chamber of aphasia. But this does not compel us to close up all the other windows, especially the anatomical and pathological windows, through which so much light has been admitted in the past.

Dr. KINNIER WILSON: It is with a certain amount of hesitation that I venture to express my views in regard to Dr. Head's recent contributions to the difficult subject of aphasia. Perusal of his papers is not enough, perhaps, to justify criticism or even to arouse full appreciation; it is evident that the student of the question must himself utilize some or all of Dr. Head's ingenious tests for the aphasic in order to be in a better position to pass comment on his conclusions.

Nevertheless, certain general considerations seem worthy of a little attention.

It is clear, in the first place, that Dr. Head's contributions must be viewed solely from the clinical standpoint. The question of localization is not raised, with the exception that he speaks throughout of "unilateral lesions," presumably in the left hemisphere. As there is no record of any pathological investigations, one cannot even be sure that the lesions have been strictly unilateral. Incidentally, I cannot agree with him that the "G.S.W. head" type of case is better for the study of the subject than vascular cases, for he himself admits that gunshot wounds tend to cause greatest damage on the surface of the brain, in addition to which there is the factor of commotio in all such patients. The fact that small hæmorrhages may catch projection fibres where they converge or diverge, is, in my opinion, much less important for the subject of aphasia than that association—i.e., transcortical, fibre systems should be involved, and these are obviously more likely to be impaired in cases where the damage is mainly cortical. The ideal case is neither the tumour nor the gunshot wound case, but that with isolated vascular lesion, the exact position of which there is opportunity to establish post mortem. Such cases are few and far between, but that increases their value when they are obtained.

Ignoring, however, the pathological side of the question, and the whole matter of localization, one may attempt to form some judgment on the clinical side of Dr. Head's work.

(1) We must be in agreement with him when he shows with clarity that the various types of aphasia are produced by dissociation of a definite mental process, which he designates symbolic thinking and expression. No one can suppose that aphasia is due to loss of motor or sensory power; if a patient has his speech musculature paralysed he is anarthric, or if paresed, dysarthric, but these are phenomena of a lower (middle) level, and the same is true of ordinary cortical blindness or deafness; these are not elements in aphasia. Dr. Head holds, further, that aphasia is not due to "diminution of general intellectual capacity," as Dejerine and others have also held in opposition to Pierre Marie, and some of my own cases may certainly be taken to bear this out. Not a few strictly limited cases of aphasic disturbance are on record to substantiate the truth of the statement. It appears to me, nevertheless, that some of Dr. Head's tests are tests of intellectual capacity, or at least of eupraxia, rather than of speech activity in the ordinary sense; in particular, his mirror test. Accepting Dr. Head's evidence from a large number of his cases of aphasia, that the patient has difficulties in imitating movements made by the examiner when the latter faces him, but can perform them easily when they are seen in a mirror, I am not able to follow the suggested explanation, that in the former group the imitative movements are "accompanied by more or less internal verbalization," whereas in the latter "no verbal symbol intervenes between the reception of the command in gesture and its execution." It seems to me largely a question of automatism. All of the patients are certain to have performed movements in front of a mirror every day of their life, so to speak, e.g., in shaving, hair-brushing, &c., and such types of movement become automatic; whereas, I do not suppose a single one of them had ever practised direct imitation movements. Their difficulty, therefore, I take to be one of practice and not of internal verbalization, and this is borne out by Dr. Head's statement that many improved very rapidly in this faculty. The test can, I think, be fairly set down as one of "glegness in the uptak" which varies enormously with the individual. Besides, not a little evidence is accumulating to suggest that automatic processes, automatisms, are located in the *right* as opposed to the left hemisphere. It may be remembered that Hughlings Jackson himself held that the right was the more "automatic" of the two; hence, one should not expect the same impairment of acquired automatisms in *left* hemisphere lesions, where one may presume the latter are located in Dr. Head's cases. The point, however, can only be alluded to in passing.

Again, the author maintains that aphasic defects are not due to destruction of images, showing by examples that many aphasics have not lost their images at all. I do not think the common view of aphasia is that in its different forms different types of image are necessarily *destroyed*, but that the patient is not able, owing to his organic disease, to awaken them when he wishes to. Thus a patient of my own after a stroke became absolutely mute. His state was one of complete motor aphasia; he had no words, not even "yes" or "no," and had apparently lost all his motor images, but on the night of the destruction of the Zeppelin at Potter's Bar he was a spectator of the wonderful sight and called out "Hallelujah," which word he has never since repeated in spite of innumerable efforts. The "engram" could not have been destroyed, and while it may be impossible as a rule to prove that images are not destroyed, for the practical purposes of speech they are "lost," and it seems to me to matter little, in a way, what has really become of them in such cases. Probably the question is largely one of the extent of the pathological lesion, and as in the majority of instances images can be shown to be retained, the lesions cannot be "knock-out" ones. After learning that in Dr. Head's strongly expressed view the affections of language from (presumably) unilateral lesions "are not based on a destruction of images," one is a little surprised to be told subsequently that he expressly excludes cases of aphasia where the patients "showed evidence of definite destruction of sensory images." It is admitted, then, that some cases are image-less. Of course, in the mind the concept of an object, say an orange, is so compact of differing linked images that it can be aroused in consciousness by stimuli from one sense avenue when others fail; Dr. Head has well shown in one of his routine tests how an aphasic can recognize an object by touch, say, when visual images fail him, and so on. Only in the most widespread cases of cortical impairment, therefore, would one expect destruction of images, and since the sensory components of the synthetized complete idea of an object are, I hold, located in widely separated cortical fields, it naturally follows that destruction of images on any wholesale scale must be a rarity. For example, too many cases have been classed as agraphia because the patient cannot write with his right hand as a result of a cerebral lesion, but too rarely is the test made with the left; for that matter, an agraphic patient, so-called, might conceivably still be able to write with the pen in his teeth, or held by his toes.

(2) This leads to a second consideration, which is, that Dr. Head holds that the familiar terms "aphasia" itself, "alexia," and "agraphia,"

should never be employed, because the disorders of language produced by a unilateral lesion of the brain are never "*exclusive* affections of speech, reading, or writing."

In another place he says—and I wish to draw special attention to the statement—the function which is disturbed by such lesions of the brain "cannot obviously be comprised under the headings of speaking, reading, and writing; for not only may the loss of power to carry out any one of them be partial, but the disturbance extends beyond their limits and affects other mental activities."

Now it may be granted at once that "pure" cases of these disorders are doubtless rare, that mixed varieties are the rule; and, for the sake of argument, one may say with Dr. Head that "inability to write is always associated with some other loss of function." It is, nevertheless, a clinical fact that one or other defect, in speaking, reading, or writing, may be *by far the most prominent* feature of a given case, so that while, for example, speaking and reading may be for practical purposes intact, writing may be all but impossible, as in a good case published in 1903 by Stanley Barnes, and similarly with alexia (combined with hemianopia) from lesions in the distribution of the posterior cerebral artery, as in a striking case of my own, and with pure motor aphasia as excellently shown by Dejerine. Rarity, even absence, of "pure" cases does not seem to me a conclusively adequate reason for abandoning useful clinical descriptive terms; especially since no one can deny the occurrence of difficulties in speaking, reading, or writing, and Dr. Head's own cases, needless to say, exemplify these admirably. If the absence of *separate* implication of any constituent in speech is to be advanced as an argument for the relinquishing of the above terms, exactly the same argument would apply to Dr. Head's own new classification of the varieties of aphasia into "verbal," "nominal," "syntactical," and "semantic" groups, since he himself admits that in most cases "two or more of these aspects of symbolic formulation are affected," and, again, "these terms are not intended to define the limits of the disturbance:" In other words, since "pure" cases of these varieties never occur either, the argument for the abandonment of agraphic or alexic varieties on the ground of their never occurring in a "pure" state falls to the ground.

(3) If, now, we take Dr. Head's new subdivisions, we learn from him that in verbal aphasia the essential defect is one of word-formation; "words are evoked with difficulty and the vocabulary is greatly restricted; enunciation is slow and halting." In addition, writing may

be extremely difficult or almost impossible, and in any case "tends to show the same errors as articulatory speech." In nominal aphasia the patient has difficulty in naming letters, words, or objects. In addition, however, "writing is gravely affected," and the power of reading is greatly hampered. The third group, syntactical aphasia, is one where the patient talks jargon. Here also, however, "patients suffering from the more severe degrees of this affection cannot write a letter," and we are told that the disorder "is essentially one of auditory balance and rhythm." Finally, in semantic aphasia there is a want of recognition of the full significance of words and phrases. The patient "fails to comprehend the final aim or goal of an action"; he cannot "formulate symbolically a general conception."

Of the clinical occurrence of these types there is, of course, no question, and we owe a debt of gratitude to Dr. Head for the emphasis he has laid on them. Their content and significance have never been so closely examined and so admirably illustrated. In particular, it appears to me sufficient attention has never been paid in this country to the grammatical aspect of aphasia, and as I personally have long been aware of its importance and have much material bearing on it, I should like to take this chance of giving my support to Dr. Head's conclusions as far as this part of the subject is concerned.

At the same time, I do not see that the "new" types, so-called, in any way *run counter to* the hitherto accepted and familiar subdivisions. Verbal aphasia closely resembles ordinary motor aphasia; the nominal variety is one commonly observed, and I may say incidentally that it is in my opinion capable of sufficiently close localization. The neurologist is aware of the association between Mills' naming centre as it has been called, and integrity of function of the upper temporal lobe, and I have seen more than one excellent example of this defect in naming from strictly limited lesions in that part of the brain. Dr. Head includes much more than naming defects, however, in his nominal aphasia, as we have seen, though this naming defect is the special clinical feature. Syntactical aphasia, again, with its jargon-aphasia, has been described often enough in the group of sensory aphasia, and I showed a perfect example of this variety at a clinical meeting of the old Neurological Society. It will be remembered that, as already noted, Dr. Head agrees the disorder is essentially one of *auditory* "balance and rhythm."

The fourth classification leads me to what I think the most significant part of the new doctrine. Perusal of Dr. Head's illustration of semantic aphasia shows that it is largely identical with agnosia, in

particular with that described by Liepmann and others as ideational agnosia. The examples furnished make this quite clear. Similar illustrations were given by myself from personally observed cases in my paper on apraxia.

Taking aphasic symptomatology as a whole, it appears to me that what Dr. Head has done is to make a new division which may be said in some ways to run across the classical divisions. Thus instead of speaking of agraphia and alexia, he speaks of verbal, nominal, and syntactical aphasia, but he admits that what is called agraphia or dysgraphia is a feature of all three, while alexia occurs at least in the second, if not in others. This again brings out the point to which I have referred above, that there is not, indeed there cannot be, any *subversion* of previous clinical knowledge in Dr. Head's work.

Dr. Head has not, as far as I have observed, used either of the terms agnosia and apraxia in his papers, obvious though it is that he is frequently describing apraxic or agnostic phenomena. Hence the significance of the remark already quoted from his paper, that in aphasia the disturbance extends beyond speaking, reading, and writing, and affects other mental activities. I believe the subject can best be understood if disorders of these "faculties," and the other mental activities mentioned by him, are looked at from the point of view of apraxia and agnosia. I do not wish to take up the time of the meeting further, except to sketch in a word what line I follow. I accept the general division of aphasia into receptive and executive defects; I hold that ordinary motor aphasia is but a part of motor apraxia, ordinarily called apraxia, and sensory aphasia of agnosia. The patient with auditory agnosia hears sounds, but does not recognize them, i.e., does not know their meaning. Among these sounds may be word-sounds, which he hears, but the content, the symbolic meaning, is for him unknown. The same is true of alexia as a variety of visual agnosia. Defects of this sort may certainly occur in unilateral lesions of the left hemisphere. On the executive side motor aphasia is a part of apraxia; the patient is not paralysed, but he cannot say what he wants to say, as the apraxic cannot do what he wants to do.

The analysis may be carried closer, and the clinical varieties of aphasia may be shown to have their counterpart on both executive and receptive sides in the matter of the "faculty" or "psychical activity" of music, and in the reckoning faculty. My view is that on the clinical side, which is all that for the moment concerns us, speech disorders, just as reckoning and music disorders, are parts of the wider impairments of function known as apraxia and agnosia.

Dr. STANLEY BARNES (Birmingham) remarked upon the very interesting way in which Dr. Head had started what appeared to be a new form of investigation of disorders of speech. He thought the scheme of examination which Dr. Head had put forward was likely to lead to more accurate results and a clearer understanding of the speech mechanism than those hitherto obtained. He himself had not had experience in examining patients on this new basis, but thought that the method now suggested was likely to carry them as much further in the analysis of speech defects and localization of speech function in the future as Dr. Head's extremely valuable researches into the various forms of sensation had enlarged their knowledge of the sensory paths. At the same time, he was rather sorry Dr. Head had published his paper in the somewhat incomplete form in which it had gone out. It would have been better if he had either included with it as published the addendum he had just read out, or waited a little longer before publishing. It gave the general impression that, after all, localization of speech was a thing which had now practically gone by the board. He did not for an instant believe that was Dr. Head's intention. He hoped that would be made clear in Dr. Head's reply.

A point he would have liked to have heard more emphasized by Dr. Head was that intellectual faculties were so closely bound up with speech that one must expect them to be represented in the same area of the brain, and that any serious defect in speech must mean a serious defect in intellect too. In some of the cases Dr. Head quoted there was a suggestion of great speech defect with no material loss of intellectual capacity; he, the speaker, found it difficult to believe that. The neurologist was dealing with patients of such varying degrees of intellectual capacity and he knew so little at first hand about the patient's intellect as it was before his lesion, that it became very difficult to estimate what was the degree of intellectual defect, if any. It was his own belief, from clinical and psychological investigation, that the two functions, speech and intellect, were largely interdependent and were represented in the same area of the brain.

It might be going further than Dr. Head wanted to go that night, but he (the speaker) would like to hear whether Dr. Head could suggest any localization, or any element in localization, with regard to varieties of speech defects. His own opinion, which he had held for several years past, was that the areas which had been hitherto suggested were too much restricted. He thought the whole mass of the information which had been received had been argued about on too narrow a basis, because

the localization of the various functions had always been assumed to be too microscopical. Thinking out the matter on purely psychological grounds, knowing something of the localization of the motor function of the brain, and adopting Hughlings Jackson's views as to the representation of particular areas, he could not believe that such an important function as that of speech could be localized in any small area of the brain: it must require a vast representation. He believed that the area of the left side of the brain devoted to speech stretched from the foot of the third frontal convolution in front to the angular gyrus behind; and from the lower limits of the supramarginal convolution above to the middle and probably the inferior temporo-sphenoidal convolution below. This large area, including most of the island of Reil, he believed to be mainly devoted to speech (both internal and external) and intellect. He believed there were no sharply-divided compartments in this area where it could be said that this or that part of the cortex was solely devoted to particular elements of the speech function, but he did believe that in the main the hinder end of this area was mainly one in which visual impressions were received and elaborated into such a form that they were ready to be received in consciousness and interpreted as speech; and that in the same way the temporal convolutions were mainly devoted to re-representing auditory impressions as speech; whilst the frontal end was chiefly concerned with the emission of speech in the form of words spoken and written.

Dr. Head had told of a variety of lesions and a variety of results. There was a suggestion—nothing more—that whether there would be one type of aphasia or the other would be determined according to the intensity of the lesion, and not according to its localization. In this matter his experience was similar to that of the last speaker and others who had spoken that night. He thought there could be no doubt that a lesion of the hinder end of the speech area would give different results from those of a lesion in the fore end. But he thought that in all these cases there would be a depression of intellect, that the whole intellectual faculty would suffer to some extent in whatsoever portion the speech area was damaged. And he agreed with Dr. Collier that the more sharply defined was the type of aphasia, the more certainly would there be a subcortical as well as a cortical lesion. He did not think there was any sharp line of definition between motor and sensory cortex, but that they were intimately intermixed, and that as one passed to the fore end of the brain it became more motor, and as the occipital end was approached it became more sensual (visual),

while on reaching the temporal lobe it was mainly auditory in type. He did not doubt that Dr. Head had explained his own cases, in the main, correctly. But, there again, he agreed with Dr. Wilson that those cases were not, essentially, any better for the purpose of determining localization than were the types members had seen. He had seen cases of bullet wounds in which the brain had been exposed by operation, cases in which the missile had crushed through the dura and those which had suffered concussion effects through a slanting blow, and it had been difficult to define the limits of the lesion, either in the surface direction or in depth. He thought Dr. Head would agree that, though it was clear that the lesions in his cases were mainly cortical, yet, to a considerable but varying extent, they might be subcortical.

He did not yet know exactly what Dr. Head meant in regard to the type of theory of which Sir James Purves Stewart spoke. He (the speaker) thought the main question at issue as between neurologists today was as to whether there was an intermediate cortical "centre" through which impulses passed, whether they were elaborated as coming from the sensory side and were coded as they were passing out in the emissary form. He agreed that there was, as yet, no absolute proof that the visual impulses did not go directly into the main mass of the speech area, that they were entering into intelligence in such a form that one could say that at such a particular place they had been re-represented or integrated to a higher stage, so that they could then reach consciousness. But he felt very little doubt that the process of integration was going on; he thought it was operative in an area not sharply defined from the remainder of the speech area, and that neurologists could use such a localization as had been worked out in the past very valuably from the point of view of localization of speech function.

J. HERBERT PARSONS, F.R.C.S.[1]: In his two admirable lectures on aphasia Dr. Henry Head has not defined precisely the psychological aspects of the question. Doubtless these aspects were fundamental to his thesis and were ever present in his mind, though the exigencies of the circumstances prevented their exhaustive discussion. The fact that he has laid so much stress on "meaning," as shown by the introduction of the term "semantic aphasia," is ample evidence that the omission is not due to oversight; it proves, in fact, that accurate psychological principles are the very foundation of his inspiration. It

[1] These remarks on "The Psychology of 'Meaning' in its Relation to Aphasia" were handed in during the discussion but were not actually delivered.

is, however, regrettable that these aspects have not been treated more definitely; in the first place, because they afford the most valuable support to his views; and in the second place, because their omission is likely to lead to misconception. Indeed, there is reason to think that such misconception has already arisen. It is readily explicable, for neurologists most interested in the subject naturally view it from the anatomical and physiological standpoint, rather than from the psychological, owing to their training and clinical experience. They are therefore liable to ignore or misconceive the exact rationale of pathological anatomical lesions in the genesis of disorders of the highest psychic activities.

The emphasis laid upon the semantic aspects of aphasia is the sign of a great advance in our conception of the disease, an advance inspired by the immortal work of Hughlings Jackson, confirmed by the previous researches of the distinguished author of the lectures, and founded upon the psychological aspect of the subject. Sound scientific psychology is therefore the crux of the question, and has hitherto not received the attention it deserves.

The psychology of "meaning" has been curiously neglected, and it is only of recent years, largely owing to G. F. Stout and the biological psychologists, of whom Lloyd Morgan is the outstanding example, that it has been analysed according to scientific principles. The work hitherto accomplished in this field is almost limited to the lower psychic activities, especially at the perceptional level. But "meaning" from the biological and psychological points of view has undergone profound phylogenetic and ontogenetic evolution, and speech is the symbolic manifestation of the highest and most complex form of "meaning."

At the lowest biological level, where the reflex arc constitutes the whole nervous mechanism, we can only conjecture the conscious accompaniments of nervous activity. It is probable that it is a vague undifferentiated sentiency, possessing a maximum of affective tone and a minimum of cognition. To it the term "meaning" is scarcely applicable, for the response is little more than a tropism: yet it would be unwise to deny the presence of a plus or a minus affective tone—pleasure or unpleasure—and this is the primitive germ of "meaning." In the higher species, in accordance with a very general psychological law, the conscious accompaniments of the reflex act have been suppressed.

At a slightly higher biological level, reflex arcs have become co-

ordinated and integrated, and the response assumes the character of instinctive reaction. It is unnecessary to labour over the conscious accompaniments of the inceptive stage of the instinctive level, for it passes by imperceptible gradations into the perceptual level which is the summit which most lower mammals have attained.

At the perceptual level, in any given first experience, sensations are aroused in the organism by physical stimuli from the outer world. Psychologically, as an impression of the given situation, sensations are objective. They undergo differentiation and subjective selection. The selected items are then reintegrated. The reintegration is of the nature of a truly creative synthesis, and issues in the form of an entirely new order of consciousness. To resume in other words, the relatively undifferentiated psychoplasm—to use a useful, but awkward and too concrete term—is differentiated into specialized affective and cognitive elements, which are reintegrated, thus undergoing a synthesis which is the "meaning" of the given experience. Perceptual "meaning," suffused with affective tone, issues in instinctive conative activity. This itself by "backstroke" supplies new modifying stimuli to the already altered psychoplasm. For, in addition to the satisfaction or unsatisfaction of the successful or obstructed instinctive reaction, the motor activities are accompanied by somatic afferent impulses modifying the cœnæsthesis which forms an important part of the conscious state.

Thus, at the end of the completed reaction the "meaning" has become enriched and complicated on the affective side by the impact of the afferent impulses derived from somatic and visceral sources, and on the cognitive side by the results of the conative activity. This altered "meaning" is stored up, and, though depressed below the threshold of consciousness, is capable of being revived and recognized on the occurrence of a cognate experience.

On the next occasion of a similar experience, in addition to the factors of the first occasion are the factors derived from recognition and revival of this concrete event which has been lived through. Learning by experience is the utilization of these revived factors, and consists chiefly in the addition of cognitive elements. The assimilation, differentiation, subjective selection, integration and synthesis of the already more plastic psychoplasm results in a higher, more complex type of "meaning"—a "meaning" which we recognize as of higher grade and explain as an intelligent modification of the hitherto essentially instinctive reaction.

In the human organism the instinctive elements, as well as innate

dispositions of a higher order, are already present in immature form as inherited characteristics. The simpler syntheses of the lower mammal are complicated by this wealth of innate factors. Not only is the first experience thus complicated, but each succeeding experience is further complicated, and experiences which are only remotely similar add their quota to the already complex mass of factors, inherited and acquired. Thus, even at the perceptual level "meaning" becomes extremely complex.

With the evolution of free ideas, and still more under the fully developed assimilation and apperception of conceptual thought, the complexity is further increased.

Hitherto no special stress has been laid upon the social environment of the individual, but we have now learnt that man is a "socius" from very early infancy. Long before a child can talk the "meanings" of the different phases of his experience of the outer world acquire characteristics which are imprinted upon them by the assimilation of special qualities derived from intercourse with his fellow creatures, of whom, of course, his mother is the most important. Though this assimilation should be regarded as a perpetual recurrence of the cycle of differentiation, subjective selection, integration, and creative synthesis, the ultimate results are equivalent to an interaction of old and new "meanings," resulting in an infinity of still newer, richer and more refined "meanings." At this stage conative activities themselves assume a synergy at a higher level, which is the dawn of true volition. The synthesis of the child's mental processes into a "self" is the product of his social intercourse, and his conative activities now show a projicience hitherto absent; to the outside observer his gestures are no longer merely passive signs of his mind's activities, but active indications of his feelings and desires. This is the dawn of language.

It would, of course, be a gross error to imagine that this brief sketch gives any true idea of the complexity of the evolution of "meaning." There is another aspect which is particularly illuminating from the point of view of aphasia, especially in association with Dr. Head's work. The analogy between the primitive undifferentiated instinct—with its "all or none" response, comparable to the "mass-reflex" of the isolated spinal cord—and protopathic sensation, has been pointed out and exhaustively elaborated by Dr. W. H. R. Rivers in his "Instinct and the Unconscious." Similarly the differentiation of the primitive instincts, with the partial suppression of the vague elements belonging to the protopathic level, is comparable to epicritic sensations.

These essentially biological and physiological aspects form the foundation of the more purely psychological aspects already considered, and are of the greatest importance in the elucidation of the phenomena of aphasia.

Enough has been said to show that "meaning" at the speech level is extraordinarily complex. Yet the methodology of analysis is now taking shape, and its application has already elucidated many of the obscurities at the perceptual level. Much yet remains to be done at higher levels. Even when this is done there yet remains the enormous field of the psychology of the concrete individual, a matter of no small importance in dealing with aphasic patients of different degrees and varieties of nature and nurture. The "meaning" of a given situation will differ for different individuals according to their inherited instincts and innate dispositions as well as their acquired experience, especially that derived from their social environment. These differences will manifest themselves in their motor responses, and above all in speech.

I have hitherto considered only the organization of thought, using that term in a wide sense. The difficult question how far the organization of conceptual thought is dependent upon speech—"internal speech," in Dr. Head's terminology—has recently received considerable attention (*British Journal of Psychology*, General Section, October, 1920, pp. 55 to 104). Certain it is that some re-synthesis occurs in the symbolization of thought which is the essential feature of speech, and that a further re-synthesis occurs in the transformation of internal into external speech. Light is thrown upon this part of the process by the study of the development of speech in the child and particularly by the psychology of reading. One elementary fact is demonstrated by the latter study, viz., that the grouping of concepts gradually develops a wider span—from the reading of letters, or at any rate monosyllabic groups of letters, the child progresses to the apprehension of groups of words. I have dealt with this portion of the subject elsewhere (*British Medical Journal*, August 22, 1914).

When it is realized that the neurologist attacks the problem at the most complex stage of its development, and that he is confronted with focal anatomical lesions which are difficult to reconcile with the psychological complexities, it is not surprising that his explanations should be crude and of only partial validity. Much of the crudity is due to the unfortunate prevalence of the term "centre." So long ago as 1904, speaking of various pupillary "centres" which have been described, I wrote: "One is inclined to wish that this term might be abolished

from neurology, so great is the ambiguity and confusion to which it has given rise. The intercommunications between the cells of the central nervous system are so complex that there are almost innumerable alternative paths whereby any given group of efferent cells may receive excitatory impulses. Our aim should be, first to determine the efferent cells governing any given movement, second to determine as far as is possible which are the afferent tracts which can lead directly or indirectly to those cells, and third to find out *how* each of those afferent tracts leads to the efferent cells. The last problem is the most difficult, and we shall find that many of the afferent tracts are very devious, and have many cell-stations on their way. Each of these may be dignified with the title 'centre,' or better, none of them" ("The Neurology of Vision," 1904, p. 50). The term—and the train of thought associated with it—is eminently unsuitable when dealing with the higher psychic phenomena, such as "meaning" and the speech which subserves it. Scientifically, the unity of the mind is correlated with a synthesis of nervous activities which are so widespread throughout the nervous system that the term "centre" is ludicrously inadequate. Yet these syntheses are dependent for their perfection upon congeries of factors which are in some degree accessible to analysis. In disorders of speech for instance, lesions on the afferent side, of which the auditory are of prime importance, will cut off some of the pabulum for differentiation, subjective selection, integration and synthesis. Such cases have been described clinically as sensory aphasias.

Dr. Head has somewhat forcibly deprecated the use of such terms as motor and sensory aphasia, alexia, agraphia, anarthria, and so on, but his protest belongs to the order of counsels of perfection. That such terms have often been unwisely chosen and inaccurately applied may well be granted, but their use as descriptive terms can scarcely be avoided with any great degree of consistency. In studying a complex "higher level" subject, of which the fundamentals are very imperfectly known, the lumping together of allied factors under one name is not only convenient but unavoidable if awkward circumlocutions are to be avoided. Doubtless semantic aphasia is a form of agnosia: both terms have their uses as well as their abuses. It is a matter of precise definition and consistent adhesion to the defined significance.

The study of aphasia is such a pre-eminent example of the necessity for the collaboration of psychologists and neurologists and of the advantages which would accrue to both sciences by more intimate co-ordination that it is, I hope, a sufficient excuse for one so unversed in the clinical aspects of the subject having the temerity to make this communication.

Dr. HEAD (in reply) said he could not imagine a task more difficult than to be questioned by the various speakers and to have to answer them unprepared. He understood Dr. Collier to be in general agreement with the clinical aspect of what he (Dr. Head) had put forward. He could not understand why Dr. Collier said that in spite of the fact that the terms used were fundamentally incorrect, and "physiologically, anatomically, and psychologically impossible," he intended to keep to them. It was for such reasons he (the speaker) had been bold enough to try to replace them by something which would be more fundamentally correct, more physiologically adequate, more psychologically possible. In speech they were dealing with a high-grade psychical aptitude far above the level of sensation. This function demanded the integration of a number of other functions before it could be carried out, and in this way speech seemed to resemble sensation; either could be upset by lesions of the brain, which did not necessarily destroy the whole act, but destroyed it in part. The mere fact that speech could be disturbed in part showed that those areas of the cortex which were attacked by these various lesions were not all of equal value. He gathered from Dr. Collier that he considered most of the lesions which produced these disturbances affected either the entering or the emissary path—i.e., in the pure forms; but with lesions of the entering path they were not concerned with speech at all, but with a disorder of some aspect of sensation. On the emissive side such a lesion should produce a pure anarthria.

Proceeding to the discussion of syntactical aphasia, he would try to unite the two parts of Dr. Collier's statement together. In the first part of his discussion on syntactical aphasia, Dr. Collier had hit on the explanation he (the speaker) had given of its origin. If a man had taken too much alcohol his legs became ataxic; he struck against chairs and tables in his progression, and the repercussion on himself told him he had not proper control of his legs. But if at the same time his speech was disorderly, he did not learn this through his somatic sensations, he knew it because he heard his speech to be wrong. Syntactical loss was due to the fact that the man could speak, but had lost regulating power over the rhythm and balance of what he said. The actual words, like all words spoken in these disturbances of language, were representative of the parts not affected. He was glad to find that, in this matter, Dr. Collier and he had hit upon the same explanation.

He was sorry to see that, later on, Dr. Collier used the terms "visual speech" and "auditory speech," as he (Dr. Head) did not know what

they were; there was speech, but not visual speech or auditory speech. When a person was speaking, his actions were carried out by physiological processes above the visual and the auditory levels. In most cases of aphasia, image-formation was not definitely impaired. True, there might be a combination of loss of image-formation and loss of speech. One of the best cases on record was that which Stauffenberg worked out in v. Monakow's laboratory in 1913. This was certainly a case of aphasia combined with what Hughlings Jackson would have called imperception.

He would like to correct the statement that his patients were selected because the lesion was thought to be cortical; with these wounds no one could be certain whether a lesion was cortical or subcortical. His object had been to see what were the actual forms assumed by destruction of speech—i.e., a high psychical function—in consequence of various organic lesions. It was impossible to suppose that the relation between organic destruction and the loss of psychical function stood in the relation of so much loss of cortex to so much disorder of psychical function. The effect of an organic lesion of the brain on the functions of speech might be compared with the result on an electric light installation of destroying a varying number of the accumulators; the area of the brain supplied the vital force, which was the basis of the physiological energy which underlay this complicated psychical act. It might easily happen that it did not disintegrate, but rather lowered the general activity and vitality of the power of speech. As a fact, however, injury to one portion of the brain was more likely, under favourable conditions, to lead to the breaking up of speech in certain directions. But before attempting to decide the situation of the lesion which produced some specific disorder of speech, it was absolutely necessary to ascertain what the disturbance was. It was of no use trying to localize the position of an unknown function on the surface of the brain. That was why he had kept away from all questions of localization at present; he wanted first to determine what function was disturbed, before putting forward views as to what lesion was likely to produce it.

Most of the speakers had accused him of being an empiric. He was delighted to hear it. The whole point in his papers was that he wanted to follow the line of English empiric philosophy dating from Locke and passing into medicine through Hughlings Jackson. The latter said, in a famous passage, "Put down what the patient does get at, and avoid all such terms as amnesia, &c."

The next point on which he wanted to insist was that these functions were not faculties; one speaker used the word "faculty" three or four times. "Faculties" came from mediæval philosophy, and had now, fortunately, been got rid of in psychology. The use of such words as "general understanding," "aphasia," "amnesia," "memory" had been deprecated by Hughlings Jackson, who pointed out that there was no such thing as memory apart from things remembered, and no consciousness apart from conscious actions. The only possible way to find out what happened in consequence of an organic lesion was, not to use words such as "reading" and "writing" which were only *a priori* conceptual terms, but to observe what did actually happen. Had he been bold enough, he would have liked to have spoken of the "*x* group of functions," which broke up into the "*a*, *b*, *c* and *d* groups." But he dare not do that. He had been obliged to give them names, and it was those names which were going to lead him to perdition; because everyone would settle upon them and think they all meant something he did not intend; another set of conceptual terms would have been invented, to load up this unfortunate subject and obscure it further. There were no such things as "types" of aphasia. A vast group of functions were employed in the acts called speaking, reading and writing, and it was these which split up in certain ways to produce the clinical forms of disordered speech.

Sir James Purves Stewart simplified the question by dividing speech affections into psycho-motor or apraxia, and psycho-sensory or agnosia. It seemed to him (the speaker) that this was a matter of words; he did not know what psycho-motor meant, and apraxia was only a convenient term for certain aspects of defective cerebral activity. Neither did he know what "psycho-sensory" meant; the sensory side of speech must consist of sensations. When it was said that the psycho-sensory aspect of speech was agnosia, this was only saying in Greek that the patient did not appreciate the significance of impressions which came to him from without. With regard to the cases described, it was extraordinary how anybody, working under the conditions surrounding Sir James Purves Stewart in Gallipoli and elsewhere, should have been able to take such photographs and such elaborate notes. It filled him with admiration. But all these cases tended to have their value decreased because they were seen in the acute period, a period which in many cases extends over many months. It was difficult to say what specific form would be assumed afterwards by cases showing such a widespread lowering of vitality. Cases 2 and 3 appeared to have had verbal loss,

with difficulty in spelling. If they could have been watched over a long enough period, he thought they would be found to be verbal aphasics. No. 4 seemed to be too diffuse to be at all definite, but No. 5 was a severe example of nominal aphasia.

Dr. Wilson seemed to think that aphasia and apraxia could be put together under one heading. Both were convenient words if they were not carried to definition. The moment one drove "apraxia" to definition one saw it did not exist. There were forms of apraxic action, which no one had described better than had Dr. Wilson himself; but when one used the word "apraxia" to explain loss of speech, it did not seem to explain more than the most simple of aphasias. He wished to get rid of all such terms.

Dr. Stanley Barnes stated that the impression had got about that localization had gone by the board. If by this was meant the localization of "alexia," "agraphia" and "aphasia," he was glad he had given the correct impression. By localization he understood that affections of certain parts of the brain were liable to produce breakdown of this group of functions in one direction rather than in another. The anatomical basis of that form of localization he hoped to put before the Section on a future occasion. He did not believe in localization as it was ordinarily stated; he did not believe in the localization of what was called "motor aphasia," or "sensory aphasia," because he did not believe in the existence of motor and sensory aphasia.

With regard to the cortical or subcortical nature of the destruction, no one would suppose that gunshot wounds were other than gross lesions, and the wonder was that after the shock had passed off any of them were found to have produced specific loss of function. Dr. Barnes laid stress on a general intellectual defect; but psychologists to-day did not believe in general intellectual defects. This could be seen in the case of memory. Jackson said there was no such thing as general memory; there were only definite things remembered. Speech was a form of intellectual activity; therefore in saying there was a defect of those processes which were responsible for speech, it was assumed there was a defect of intellect. But this was a specific loss of function and there was not that gross widespread defect of intellectual aptitudes as was found in the slighest case of dementia.

Publications Recently Received.

Studies in Word Association. Under the direction of C. G. Jung, M.D., LL.D. Authorized translation by Dr. M. D. Eder. Pp. 575. London: William Heinemann, 1918.

Nearly half of this large volume is devoted to the study of the value of the response to the stimulus word. Jung and his co-workers have for this purpose investigated thirty-eight normal persons in great detail under varying conditions, and they have brought out interesting and in some ways unexpected results. As might have been surmised, they were able to show that on distraction whether external or internal, and in states of fatigue, the associations were of a more superficial kind than when these factors were absent; but a surprising result, obtained from the study of normal people, consisted in the fact that, other things being equal, educated people gave more superficial reactions than the uneducated. "The uneducated knows the word less as a verbal sign than as something with a meaning. Hence, single words are apprehended by them according to their meaning in some imaginary sentence; to the educated the stimulus word remains merely a word without any special meaning." From the different kinds of reaction which the experimenters classified, Jung has been able to make further progress with his psychological types.

To the psycho-analyst the main outcome of these investigations is that the importance of marked prolongation of reaction time as a complex indicator remains unimpaired. Though fatigue and external distraction may cause prolongation, they do not do so with the same success nor in the same selective way as the internal distraction of emotion.

In an elementary chapter Professor Bleuler seeks to demonstrate the fact of the unconscious. Unfortunately nearly all his proofs are for something of the nature of the fore-conscious or of a co-conscious which reasons after the same fashion as the conscious, the part of the subconscious which enables us by mental process to avoid jostling passengers in the street when we are thinking of something else. That is not a part of mental process which is in need of much demonstration. Its conception arouses no opposition, and it is probably accepted by everyone. What is needed is clear proof—and such is not difficult to find—of a subconscious whose contents never emerge into consciousness except by distortion, although they have great influence on our thoughts and actions.

There are useful chapters on word reactions in psycho-analysis and treatment, on the psycho-galvanic reaction and on associated physical changes.

It may be said that the work is one of great value, that it strengthens in every way the doctrines of psycho-analysis; for it is a record of facts derived from painstaking work, and is free from the speculative views which run through much of Jung's later work.

Dr. Eder deserves the highest praise for the translation; so excellent is it that the book might have been originally written in English.

The Psychology of the Special Senses and their Functional Disorders. (The Croonian Lectures delivered before the Royal College of Physicians in June, 1920.) By ARTHUR F. HURST, M.A., M.D., F.R.C.P. Pp. 123. London: Oxford University Press, 1920.

In these lectures Dr. Hurst gives an account of his observations on cutaneous sensibility, visceral pain, superficial reflexes and affections of the special senses, particularly in connection with the war neuroses. He accepts Babinski's definition of hysteria as "a condition in which symptoms are present which have resulted from suggestion and are curable by psychotherapy." He also agrees that all the ordinary forms of loss of somatic sensibility and limitation of the visual fields found in this disease are suggested to the patient; he gives instances to show, however, that in some cases during the war the suggestion came from a gross nerve injury. But in support of this view, with which all will agree who have had the opportunity of making observations on wounded soldiers, he cites cases where the "anæsthesia" occupied the whole area usually given by anatomists as the supply of the ulnar and median nerves. There is no note to show how this loss of sensibility was discovered. The usual form assumed in our experience by such hysterical conditions is for the whole anatomical area attributed to the injured nerve to be insensitive to prick, a condition which never occurs even after complete division of either the ulnar or median nerves. It is not an hysterical perpetuation of the condition produced by the injury but a superposed state due to suggestion by the medical examiner.

The author believes that the abdominal and plantar reflexes can be abolished in uncomplicated hysteria, although precautions are taken to protect the skin of the abdomen and the foot from cooling. He also considers that in the larger number of instances tenderness of the skin in cases of visceral disease is due to suggestions on the part of the observer.

He gives several cases of hysterical deafness and states that the auditory motor reflex may be absent and vestibular tests alone can show whether this condition is hysterical or not. Total blindness, even when accompanied by loss of reaction of the pupils to light, may be hysterical and undergo rapid cure.

Festschrift zur Feier des 70 Geburtstages von Hofrat Professor Dr. H. Obersteiner. Edited by Dr. OTTO MARBURG. In two parts, pp. 502. Leipzig and Vienna: Deuticke, 1917-18.

Professor Obersteiner attained his 70th birthday in 1917, and these two volumes were compiled by his pupils in his honour. They contain sixteen papers on a variety of neurological subjects, such as concussion of the spinal cord, gunshot wounds of the visual centre, psychoses and neuroses of war, loss of sweating with lesions of the spinal cord, nervous disorders of hearing due to explosions, and a beautifully illustrated paper on encephalitis lethargica. They form a worthy tribute to the eminent man to whom they are dedicated.

Arbeiten aus dem Neurologischen Institute an der Wiener Universität. Founded by Hofrat Professor Dr. H. OBERSTEINER. Edited by Professor Dr. OTTO MARBURG. Volume xxi, parts 1 and 2, June, 1914; part 3, February, 1916. Volume xxii, part 1, July, 1917; parts 2 and 3, October, 1919. Volume xxiii, part 1, October 1920. Leipzig and Vienna: Deuticke.

This well-known series of Studies from the Neurological Institute, founded by Professor Obersteiner in Vienna, appeared intermittently during the War under the editorship of Professor Otto Marburg, the present director.

The volumes which have recently come to hand contain papers on the anatomy and physiology of the vestibular nerve, the development of the cortex cerebri, several studies of the structure of the cerebellum, together with a long account of the comparative anatomy of its nuclei. Other papers deal with the relation of multiple sclerosis to syphilis, the pathological histology of the cerebellum in general paralysis, and of encephalitis lethargica. Recent experience of gunshot injuries is responsible for "Auto-regeneration of the Peripheral Portions of Severed Nerves," and "Pathology of War Injuries of the Spinal Cord." The editor gives a short account of a case of amnesia and of the structure of the Pineal Gland.

Military Psychiatry in Peace and War. By C. STANFORD READ, M.D. Pp. 168. London: H. K. Lewis and Co., 1920.

This volume is recommended to psychiatrists, psychologists and neurologists as presenting on the whole a reasonable biogenic view of the development of the graver mental disorders of soldiers. It is written by a psychiatrist of wide experience who has been led through modern psychological investigations and a realization of the inadequacy of the pathology advocated by the older alienists to recognize a psychogenic origin of many of the psychoses.

Between August 1914 and May 1919, 12,320 patients suffering from mental disease passed through "D" Block, Netley, which was the Clearing Hospital

for such cases from abroad. Of these, 331 were officers and 11,989 N.C.O.'s and privates. For a considerable period of the war the author was in charge of the psychiatric wards at Netley, and 3,000 patients passed through his hands. He was able to follow up the subsequent histories in the majority of cases, and in consequence was in a position to test his view that mental conflict is the most important ætological factor in the production of war psychoses.

One of the interesting and possibly far-reaching conclusions to which he has arrived is that too much stress has been laid upon exhaustion and alcoholic excess as causative agents by English and French observers. These factors in dementia præcox, paranoid, confusional, and manic-depressive states, &c., must be relegated to a position of secondary importance since they appear to be potent for harm only in so far as they aid the deleterious effects of mental conflict. This he believes to be motivated in the psychoses mainly by the sexual instinct and not by the instinct of self-preservation as in the psychoneuroses.

The largest number of his patients came under the groups of dementia præcox (20 per cent.), confusional insanity (13 per cent.), and mental deficiency as such without superimposed psychoses (13 per cent.). The prominence of paranoid tendencies in the early phases of all psychotic disorders in soldiers is noteworthy, and is to be explained as a direct consequence of the training and environment of the soldier and the liability for the manifestly abnormal individual to be the butt of his companions.

The absence of an index is largely compensated for by the arrangement of the material in short chapters.

Standard Method of Testing Juvenile Mentality by the Binet-Simon Scale and the Porteus Scale of Performance Tests. By NORBERT J. MELVILLE. Pp. 157. Philadelphia and London: J. B. Lippincott Co., 1920.

This book, which has appeared in a second enlarged edition, is a clear and concise account of a psychological method for the diagnosis of the intellectual level of children of the school age. The method adopted is largely based upon that employed by Binet and Simon, although certain modifications have been introduced as the result of experience gained from organized mental surveys in a number of American public schools. As an essential for statistical purposes the tests are standardized, but due recognition is given to the necessity for special records of variations in each individual examined.

The procedure here advocated, if used on a large scale by trained observers, should give invaluable information upon not only normal and abnormal juvenile mentality, but also the intellectual status of criminals and the feeble-minded.

Part 2 of the book is occupied with descriptions of the various tests and useful directions to examiners are appended.

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EDITOR.